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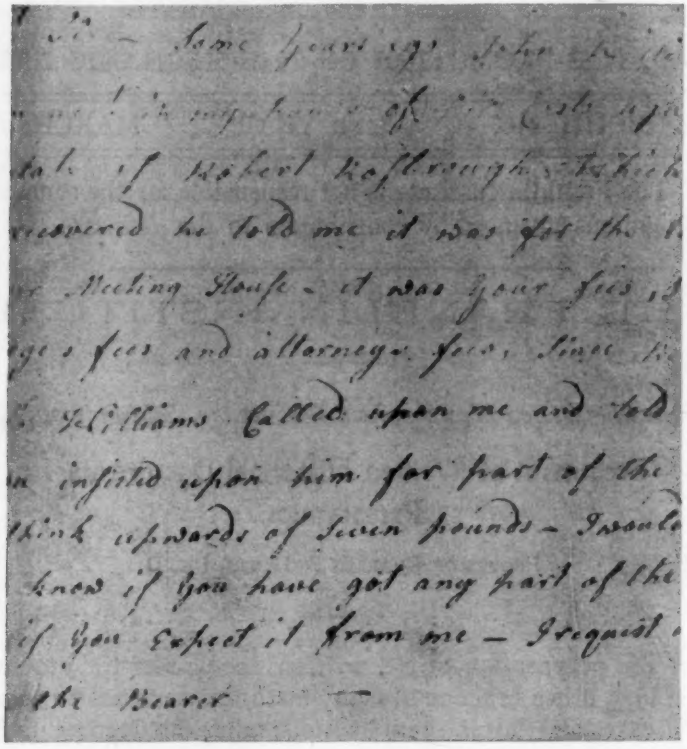
(*Read at the Stated Meeting, held Wednesday, February 20, 1907*)

Treatment of Written Historical Documents for Preservation.

PROFESSOR CHARLES F. HIMES, PH. D.

In the preparation of old written documents for mounting and filing, it is a practice of many historical societies to remove the creases and flatten them by moistening the documents first, rather thoroughly with water, by passing a sponge or brush filled with it over the face, and then subjecting them to pressure between blotters. A sheet of less absorbent paper, as blank newspaper, is in some cases placed next to the document. Whilst in some or even many cases this treatment may not produce a perceptible change in the intensity or color of the writing, or affect its clearness, it does have in others a very perceptible effect in both respects, and it may almost be

assumed that in all it has a tendency to impair the vigor and permanency of the writing. In many cases the dampened ink will set off under the pressure onto the blotters, and whilst the writing may still be clear and legible, the hard protective outside coating of the ink will be removed, or rendered more pervious to atmospheric and other influences and a strong, vigorous writing give place to one of feebler appearance. It is



also a pertinent question as to how far moistening the paper may affect the size and physical condition of the paper, and thus the strength and permanence of the paper as well as the writing. These remarks apply of course equally to such documents as it may be found necessary or advisable to reinforce with some light, semi-transparent fabric, as silk gauze, and in such cases it is worth considering whether reinforcement of the

weak parts, generally the folds, by strips of such material might not be sufficient and preferable. Such strips could be attached more easily, by any one, without much practice, by means of a quickly drying photographic paste, without the same effect upon the writing or paper.

Whilst with many documents of secondary importance these considerations may make little difference, with others it is a grave question whether the flattening of documents is not accomplished at considerable loss or risk in many directions, and with no corresponding gain in legibility, and most likely loss under magnification.

The accompanying half-tone of a document, one half of which was treated as described, and the other half simply subjected to pressure at the same time, will illustrate and emphasize the preceding statements. The document bears date "1789," the writing is uniformly black and distinct, and the paper in excellent condition. The print, direct from the negative, one of a lot, shows plainly the treated portion, but not as distinctly as the document itself. The document, selected from a number, was the first experimented with in this way.

It seems in place to add, that such variation in *intensity* of documents, so to speak, may be greatly reduced in the photograph, or even eliminated, in many cases by suitable photographic manipulation in the production of the negative or print.

STREAM POLLUTION BY ACID-IRON WASTES.

A discussion of stream pollution by acid-iron wastes, based on investigations made at Shelby, Ohio, has recently been published by the United States Geological Survey as Water-Supply and Irrigation Paper No. 186. The author, Mr. Herman Stabler, gives the history of the pollution and the attendant litigation, explains the effect of acid-iron liquors upon sewage purification processes, describes the conditions along the streams, and discusses methods of disposing of acid-iron wastes without discharge into watercourse or sewerage system. The investigations conducted by Mr. Stabler were made under a co-operative agreement between the United States Geological Survey and State Board of Health of Ohio, each bureau participating equally in the expenses involved.

Stream pollution by iron works effluents has always been an important question in countries where the iron industries are prominent. The polluting liquors, commonly known as "acid-iron" liquors, are derived from the "pickling process" common to galvanizing, tin plating, tube and sheet iron treatment. This "waste pickle" is not a desirable addition to streams (1) because it produces a reddish discoloration and turbidity, mak-

ing the stream waters, bed, and banks unsightly; (2) because, by reason of its avidity for oxygen, it robs the waters of their natural supply of this essential gas and thereby, when it is present in comparatively large quantities, causes the death of fish, and (3) because it gives rise to a large quantity of iron in the stream, and thereby impairs the usefulness of the water for domestic and laundry purposes and for certain manufacturing processes.

This report is for general distribution and may be obtained on application to the Director of the United States Geological Survey at Washington, D. C.

PRODUCTION OF GAS, COKE, TAR, AND AMMONIA.

A report on the production of gas, coke, tar, and ammonia at gas works and in retort coke ovens during 1905 has been prepared by Mr. Edward W. Parker of the United States Geological Survey and is now ready for distribution. It is supplementary, in a measure, to the reports on the production of coal and the manufacture of coke, and is made in response to a demand from producers of gas and coke and the by-products of tar and ammonia, for statistical information on these subjects.

The present report includes, in addition to the statistics of the production of gas, coke, tar, and ammonia at gas works and in by-product coke ovens, a statement of the production of the quantity of gas and tar produced at water-gas works using crude oil for enriching purposes. These statistics have not been considered in any of the preceding reports. At some of the gas houses oil is used with the coal in the production of gas, but the entire production is included in the statistics of coal gas.

The total quantities of these products in 1905 was 40,454,215,132 cubic feet of gas (not including that lost or wasted) 5,751,378 short tons of coke, 80,022,043 gallons of tar, 46,986,268 gallons of ammonia liquor (equivalent to 22,455,857 pounds of anhydrous ammonia), and 38,663,682 pounds of ammonia sulfate, against 34,814,991,273 cubic feet of gas, 4,716,049 short tons of coke, 69,498,085 gallons of tar, 52,220,484 gallons of ammonia liquor (equivalent to 19,750,032 pounds of anhydrous ammonia), and 28,225,210 pounds of ammonia sulfate in 1904. The total value of all these products in 1905 was $56,684,972 against $51,157,736 in 1904.

OIL AND WATER GAS.

Returns were received from 477 oil and water-gas producing companies, and these show that the total production of water gas in 1905 was 82,959,228,504 cubic feet. Of this quantity 5,547,203,913 cubic feet, or 6.7 per cent., were lost by leakage, etc., leaving 77,412,024,591 cubic feet as the net production obtained and sold. As the quantity of gas made and sold at coal-gas and by-product coke oven works was 40,454,215,132 cubic feet, it appears that the consumption of water gas, and gas made from crude oil was nearly twice as much as that made from coal. It also appears that while the average price of coal was in 1905 was 81.4 cents per 1000 cubic feet, that of oil and water gas combined was a fraction of a cent in excess of $1 per 1000 cubic feet. Still further comparison shows that whereas 66 per cent. of the production of coal gas was sold as illuminating gas, 77 per cent. of the combined production of oil and water gas was used for this purpose.

ELECTRICAL SECTION.

(Stated meeting held Thursday, December 27th, 1906.)

(*Concluded from February, 1907, vol. clxiii, page 148.*)

The First Atlantic Telegraph Cable.*

By John Mullaly.

And now, having arrived at this point, it is essential for a further investigation of our narrative, to consider in detail this marvelous but simple production of mechanical ingenuity, this great electric link which binds worlds together in immediate intercourse, and along whose slender copper core the subtle electric current courses with the speed of thought. The mechanical process by which the cable is produced is simplicity itself; but it is with the material of which it is composed that we have to do. In the first place the most important part of the covering is the gutta percha, a peculiar gum obtained from a tree which grows in the East Indies and which possesses not only the property of resisting acids, but which is also one of the most perfect non-conductors of electricity known to science.

Up to the time of its discovery and application to this particular use, all attempts to make a perfectly insulated submarine conductor had failed. Narrow tracts of water, it is true, had been crossed by sub-aqueous wires, but the impossibility of establishing communication between distant points separated by water had become clearly apparent.

In October, 1842, as I was informed by Professor Morse, he connected Governor's Island with the Battery by a conductor which was insulated, or covered with a coating of tar, pitch and

*Read by title.

India rubber, and although he succeeded in passing a current through it after its submersion, he was convinced that the insulation thus effected could be only temporary. But here was a new material, the peculiar properties of which became known just at a time when science had tried all its former resources and appliances without effect.

The conductor in the center of the first Atlantic telegraph cable was composed of seven small copper wires, each of which was as thin as an ordinary pin. In this first ocean cable, to which the present description applies, these copper wires were twisted spirally, in which form, it was claimed, they were capable of being extended a considerable portion of their length before parting. Then should six of the seven part, the seventh, it was asserted, would have sufficient tenacity to maintain the electrical continuity. To insure the complete insulation of the conductor, it was covered with three layers, or coatings of gutta percha, over which was wound a serving of hemp steeped in a composition of tar and pitch. The unfinished cable next received the outer covering, or wire armor; after which it was passed through tanks of tar before being subject to the process of coiling, the tar protecting the iron from rust until submerged; but when once safely deposited on the bottom, all the corrison to which it would then be subjected could not affect the conductivity insured by the insulating property of the inner covering of gutta percha. In the manufacture of the three thousand miles of cable there would be, it was estimated, a liberal margin over and above the sixteen hundred and forty nautical miles, or nineteen hundred and fifty statute miles, which was the distance between the connecting points in Valentia Bay, Ireland, and Trinity Bay, Newfoundland.

Three thousand miles of cable were, therefore, manufactured and coiled on board the Niagara and Agamemnon by the month of July, 1857; and both ships having received the machinery required for the process of submersion, proceeded to Queenstown, Ireland, which had been selected as the place of rendezvous. From Queenstown the whole Telegraph Squadron proceeded on its course. It consisted of the two above-named principal, or cable ships; the Susquehanna (which took no part in the subsequent expedition of 1858), to at-

tend upon the Niagara; the British war steam frigate Leopard, as escort to the Agamemnon; the Cyclops, to keep the course; and two small steamers, the Advice and the Willing Mind, to assist in landing the cable in Valentia Bay. From that point it was decided that the laying of the cable should be begun, although the proposition to commence in mid-ocean met with more favor.

Advantage was taken of the time required for the passage from Queenstown to Valentia to test the machinery on the Niagara, but the trial proved so unsatisfactory that it caused considerable anxiety as to the issue.

On the 5th of August the operation of taking the cable ashore was effected in the presence of a great multitude from all parts of Ireland assembled to witness the public and official ceremonies with which the occasion was to be celebrated. It was, in fact, one of the greatest events that had occurred in the history of the country, and the enthusiasm of the people was unbounded.

The end of the cable was landed in the midst of the wildest excitement; the spectators, unable to restrain their impatience till the cable reached the shore, rushed into the water as with a common impulse, and joining the men of the Niagara, ran with it up the beach, bearing back the dense crowd that vainly endeavored even to participate in the honor of having touched it with their fingers.

In the evening there was great rejoicing in the little village of Knightstown and the merrymakers kept up the festivities throughout the night. In the morning the Niagara resumed the work of paying-out, and with her bow to the westward, proceeded at the rate of two miles an hour. This was the shore cable, and as it was much thicker and heavier than the deep sea line, the paying-out process was consequently more tedious and difficult. The misgivings felt as to the working of the mechanism were confirmed on the very first trial, which proved a signal failure, hardly two miles having been paid out before the dreaded fracture occurred; the cable had surged off from the grooved wheels of the paying-out machine, and becoming entangled, snapped like a pipe stem. Several hours were lost in repairing damages, when the work was resumed with better success.

The 7h, 8th, 9th and 10th of August saw the Niagara still laying the cable and the hopes of the desponding began to revive. All went well till the night of the 10th, when an interruption in the electric continuity occurred, lasting over two hours. It was a phenomenon which the electricians in vain tried to clear up; but in the midst of their perplexity and when they were about to give up in despair, the continuity returned as suddenly as it had disappeared. It was as inexplicably restored as it had mysteriously been interrupted.

But our rejoicing was premature; our good fortune was to be short-lived, for about a quarter to four the following morning the cable again parted in consequence of another excessive strain to which it had been injudiciously exposed; the machine was temporarily paralyzed and the broken end of the line swung loosely from the stern of the Niagara.

This time the cause of the disaster was no mystery; the engineer in charge, acting precipitately under the impression that there was an excessive expenditure of the cable, had put an undue pressure on the brakes. The result was inevitable: the wheels of the paying-out machine ceased to revolve and the cable parted under the increased strain.

There was a sad scene on board our ship when it was announced that we were to return to England bearing the depressing and mortifying news of our defeat and of the grave disaster to the enterprise. We had grown over-confident from our last four days of almost uninterrupted progress and were hopefully calculating the number of days and hours it would take to reach the bleak and mountainous shores of Newfoundland. We thought of home and of the great expectant public who were eagerly awaiting the hour that would bring them the glorious news of our success; and our hearts throbbed more rapidly as the hope grew day by day into the semblance of a living reality.

But here we were two hundred and sixty-six miles from our starting point on the Irish coast and with three hundred and thirty miles less of cable than we had on board when we steamed, four or five days before, out of Valentia Bay. As to the financial loss, it amounted to over one hundred and fifty thousand dollars for the cable alone.

Although depressed, we were hopeful of ultimate success,

for having laid so much of the line we not unreasonably concluded that but for that unlucky mishap of the strain, we might have reached our destination. Before this the gravest doubts were entertained as to the practicability of the work, for it was believed and persistently asserted by the skeptics, that it would be found impossible to submerge the cable in the great depths; but here we were above the great depths already and the broken line lay on the Telegraph Plateau two miles beneath the keel of the Niagara. Over seventy miles had been laid in water from fifteen hundred to two thousand fathoms deep when the fracture occurred, and what more convincing proof could be required of the feasibility of the undertaking?

About six o'clock on the morning of the 11th of August a meeting was called in the cabin of the Niagara, at which the engineers, the electricians and the Commanders of the Squadron were present. At this meeting it was decided that the experiment of splicing the cable between the two ships should be made with the intention of commencing the operation from mid-ocean on the next trial. Having, after careful deliberation, arrived at this decision, Mr. Field started at once for England on one of the escorts, and on landing proceeded direct to London, where he informed the Directors of the company of the results of the expedition. Although it was now the middle of August, it was proposed to make another attempt in October, by which time, it was believed, an additional supply of cable, to replace what had been lost, could be manufactured. That month was said to be one of the mildest of the year, but it certainly did not sustain its reputation this time, for it proved to be one of the most boisterous and tempestuous that ever occurred on the Atlantic. It was fortunate, therefore, that the work was postponed till the summer of 1858, by which time there would be ample opportunity to devise and construct more perfect machinery, as the breaking of the cable on the 11th of August was partly attributed to the paying-out apparatus.

The Niagara having discharged her cargo in Plymouth, returned to New York, where she arrived on the 20th of November. The Agamemnon had also discharged her portion of the great sea-line, and the two ships were put out of commission until they should be required to resume the work. Mr. Field

had reached New York in September, having previously ordered the manufacture of about nine hundred additional miles of cable. As the distance between the two termini is, as stated, 1950 statute miles, the two ships were to be allowed 1500 miles each, which was regarded as a most liberal allowance to meet every possible contingency.

From October of 1857 till March of 1858 the public heard little of the great enterprise and settled down into the firm belief that it was not only impracticable, but that the men at the head of the undertaking were either visionaries, or were deceiving the stockholders, playing on the credulity of those who, in spite of the signal failures which had thus far attended every trial, might be induced to invest their money in what these keen and knowing skeptics did not hesitate to denounce as a gigantic bubble. Nor was this at all surprising, for there was a certain savant, who in the course of an abstruse and scientific lecture before a London audience, had proved that the thing could not be done; that it was beyond the attainment of human genius; in a word, that all the resources of science were unequal to the task. Nor was this all, for he had actually received a gold medal in testimony of the high appreciation in which his marvellous acumen and learning were held. It may be remembered that this particular scientist was preceded many years before by another learned and distinguished oracle of his day, a certain Dr. Dionysius Lardner, who wrote an elaborate disquisition to prove that it was impossible to propel a vessel by steam across the Atlantic for the all-sufficient reason that no vessel could be constructed to carry the necessary amount of coal required for the trip. Who thinks of the skeptics now?

The public, as stated, heard little or nothing of the enterprise from October of 1857 till March of 1858; but preparations were being made persistently and quietly for the resumption of the work during the month of June of the latter year.

Mr. Field accepted the office of General Manager at the urgent solicitation of the Board of Directors, and entered on the duties of his new office in January, 1858. Before leaving the United States for England, however, he applied to our Government for leave of absence for Mr. Wm. E. Everett, one of the most skillful and experienced officers of our Navy, and having

succeeded in the application, both gentlemen left New York on January 6th, 1858, in the Persia, for Liverpool, where they arrived on the 16th. Mr. Everett had been on the expedition of August, 1857, as the Chief Engineer of the Niagara, and while acting in that capacity had rendered very efficient service. But the task which he had now to perform was of a novel character, a task that demanded mechanical ingenuity and skill of the highest order. He was called on to devise and build a machine that would *surely* lay the cable, which machine, if successful, would save the company from disaster and bankruptcy. It is sufficient to say that he fully realized the responsible nature of the duty imposed upon him, and he entered on its performance with an assiduity equal to its importance.

In one of the dirtiest, dingiest and most out-of-the-way places of London called Gravel Lane, stood the factory in which this apparatus was to be made, and here, in this building, itself in strange harmony with the broken-down, ruinous aspect of the locality, Mr. Everett worked night and day in the construction of the machine that *did* lay the cable. At the end of three months he succeeded in the production of an apparatus that the best engineering talent in England agreed was the most perfect that could be made, a decision which was fully justified by its performance on the final expedition.

This machine consisted of four wheels with four grooves on each, each groove being four and a half inches deep. In these grooves the cable ran, and the speed of paying out was regulated by the action of brakes. The principal feature of the brakes was their automatic, self-releasing character, by means of which the pressure could be safely increased from one to two, or three thousand pounds. There was, in addition to this, another safe-guard, so that if the break accidentally failed to act, the strain on the cable might be immediately released. At the dynamometer, the indicator which told the amount of strain, stood a man holding the handles of a wheel similar to that used in steering ships; and the moment the indicator registered a heavier strain than the cable could safely stand, the pressure on the brakes was released by a few turns of the wheel, thus allowing the line to pass out more freely and with less risk.

Such, in brief, is a description of the Everett Paying-out

Machine, and it is not too much to say for its efficiency that it was an important, if not an indispensable factor in the successful accomplishment of the work of submerging the Atlantic Telegraph Cable, the precursor of the numerous lines that now unite Europe and America.

Two such machines were placed respectively on the Niagara and Agamemnon in the month of May, and by the end of that month the coiling of the cable on both ships was also completed. And that same coil was a wonderful thing in its way and the men engaged in the coiling were a wonderful band. They called themselves the "Cable Guard of the Niagara," and to the vigilance and skill with which they executed their part of the work the success of the expedition was in no small measure due. Stalwart, hardy, earnest workers, who, without a dollar in the enterprise, felt as much interest in it as if each man was the owner of a share of its stock. How faithfully and patiently they worked only those who saw them could tell. Coiling away foot after foot, yard after yard, mile after mile of the fifteen hundred miles of the tarred rope, they worked from morning till night and from night till morning on these huge bobbins, of which there were no less than seven on the three decks and hold of the vessel, packing away every fathom as neatly as a thread is wound upon a spool. From day to day and week to week they labored until the fifteen hundred miles had passed through their hands and each one of the cable circles was as full as it could hold. And while they worked they had their jokes, and their yarns of the oldest and the newest brand.

The 29th of May the Niagara and Agamemnon, accompanied by their escorts, the Gorgon and Valorous, started on a trial trip to the Bay of Biscay, where the splicing and submerging of the cable was tested and the paying-out machine was operated to the satisfaction and approval of the engineers. The squadron then returned to Plymouth, arriving at that port on the 3d of June. On the 10th of the same month they left Plymouth for the rendezvous in mid-ocean, where both vessels were to meet, splice the cable and start for the eastern and western termini of the Sub-marine Telegraph.

The weather was all that could be desired; the sun shone out from an almost cloudless sky, and the wind, which at times

sweeps with destructive violence along the rock-bound coasts of Cornwall and Devonshire, was subdued to a gentle zephyr. A numerous array of friends had assembled on the end of the Plymouth Breakwater, and under the shadow of its lighthouse, to bid us farewell. In a few hours the shades of evening had closed down on the scene and shut out from our view the last projecting landmark.

During the first three days the weather was no less favorable, but on the fourth an ominous change came over the face of the heavens; the bright skies had disappeared and large masses of threatening clouds obscured the sun. The violent gusts of a storm which was about to break upon us in all its fury, swept over the darkening surface of the ocean; the waves which but a few hours since were but as the ripples on a stream, were lashed into foam by the increasing force of the gale, and swelled into mountainous proportions. Everything that was necessary was done on board our ship in preparation for the coming storm; all sails were reefed, and the watchful supervision of our captain and officers saw that nothing was left undone for the security of our noble vessel and her costly freight, on the safety of which depended the realization of one of the grandest of human enterprises. The same precautions were taken on the Agamemnon, and the whole fleet kept on its course for the ocean rendezvous, seven hundred miles away. Every hour added to the violence of the storm; the squalls came up thicker and heavier and the huge waves surged and foamed about the ships in their fierce wrath. Still the Squadron held on its course, the unerring needle their only guide to that point where there was nothing but sea and sky.

For nine long and weary days they battled with one of the wildest storms that ever swept the stormiest of oceans. There was no cessation in the combined fury of wind and waves. The Niagara and Agamemnon kept company for several days, but the Gorgon and the Valorous had disappeared soon after the beginning of the gale. But the former also became separated, and had then to fight it out with the warring elements alone and unseen. Captain Preedy, the commander of the Agamemnon, was obliged to change his course because of what, as we presently learned, seriously endangered the safety of his ship. The immense coil which was placed in the hold,

and which contained over a thousand miles of the cable, had, in the rolling of the vessel, worked loose and into tangled masses until about one hundred miles of it were forced out of the circle and tossed about in the hold, burying beneath it all who had the temerity to approach. In addition to this serious situation it was feared that one of the deck coils would work loose also, and it was evident that under such circumstances, no human strength could save the Agamemnon. But the coil did not shift, and when on the eighth day the gale began to abate, the sky to clear and the waves to go down, there was many a glad heart on the British vessel. Only those who "go down to the sea in ships," and who have had such experiences, can appreciate the feelings with which they greeted the return of fair weather.

Worthy of the highest praise were the captains and officers of the Agamemnon for the coolness displayed under circumstances that might well appal the hearts of the bravest. Night and day they were on deck, and with an energy that was almost superhuman, they kept up the fight, inspiring their men with their own heroic courage, till they saved their ship from what seemed inevitable destruction.

Of the Niagara, which was the newer and in all respects the better ship, it can be truly said she bore her burden more lightly and passed through the storm almost unscathed. She had been constructed by her designer, George Steers, the celebrated builder of the Yacht America, which won the now historic race off Cowes over half a century ago and the prize cup that we have held ever since against all competitors.

The storm over, the reunited vessels set out with as little delay as possible for the rendezvous once more, though not for the last time, and reached the appointed place on the 25th of June. It was found impossible, however, to begin operations until the tangled coil on the Agamemnon was taken up and recoiled, which consumed a whole day in the operation.

On the 26th the work of splicing the two ends of the cable was done, the Niagara and Agamemnon being held together for the purpose by a hawser eight hundred feet long. As this was one of the most important details of the work, a somewhat detailed description is necessary to a proper understanding of the process. In the first place, the two ends were com-

pletely denuded of the outer wire, the hemp serving, and, finally, of the gutta percha, so that nothing was left but the copper core, or conductor, about six inches of which were exposed. The two ends thus prepared were laid together and secured by a binding of copper wire. This done, the second part of the process consisted of the soldering of the spliced wire, an additional binding and soldering following to reinforce the first binding. It was now ready to receive the gutta percha, which was laid on in a plastic state, to which it was brought by the flame of a blow-pipe in the hands of the operator, or splicer. The hempen strand, or serving, was next wound round the gutta percha, and over this was interlaced the outer wire. The spliced portion was still further strengthened by a wrapping of strong cord. This completed the operation; but as this portion of the line required still further protection it was relieved from all strain by two iron-bound loops which were placed one on each side of the splice and then drawn together in such manner as to leave the splice free from strain. A crescent-shaped piece of wood, about eight feet long, was next procured and the cable laid in a groove cut on the surface of the wood and secured in its place by a piece of flat iron of the same form and size as the wooden crescent.

At least two hours were passed in this operation and it was with a feeling of relief that we saw the splice with a heavy weight attached, descend slowly into the water, and the motion of the paying-out machine informed us that it was on its way to the submarine plateau two and a half miles down. A red flag was hoisted on the Agamemnon as the signal that she had commenced paying out, and soon after the cable was running over our stern at the rate of three miles an hour, both ships proceeding as slowly as possible to give the spliced portion time to reach the bottom. Hardly, however, had two and a half miles been paid out from our ship before the cable was torn apart, having slipped out of one of the grooves of the machine. It was, it seems, impossible to avoid the accident at the time, and it was, therefore, regarded as of slight importance, as it had not been caused by any deficiency in the working of the apparatus, and but little cable had been lost by the accident. So the ships returned once more, made another splice, and steamed away, each on its homeward course. But

they were again doomed to disappointment, for after forty more miles had been submerged from each of the cable ships an unaccountable break of the electrical continuity occurred, a break for which no satisfactory explanation could be offered. The electric current had ceased, and after holding on by the cable for several hours we were obliged once more to cut it and make for the rendezvous.

The 28th of June the Niagara and Agamemnon met again in mid-ocean; but inquiry among the electricians on either ship failed to elicit any information as to the cause of the interruption of the current.

This untoward incident caused the gravest apprehensions, as it was impossible to tell what agency might be at work at the bottom of the sea, an agency which we could not hope to contend against, because unseen. However, here we were preparing for still another trial. The splicing process was repeated for the third time and the ships started for their separate destinations. The work went on fairly well until each vessel had laid about one hundred and forty miles, when the cable again broke at the stern of the Agamemnon.

In accordance with the agreement made in anticipation of such contingency, the Niagara having gone over the stipulated distance of one hundred nautical miles, returned to Queenstown to coal, preparatory to starting on the third, and, as it proved, the final expedition. The Agamemnon, however, under the impression that we had not traversed the stated distance, returned to the rendezvous and waited there several days, when she, also, returned to Queenstown. The Niagara reached that port on the 5th of July, and the Agamemnon seven or eight days after.

Again we were obliged to carry the news of our defeat and to add another chapter to the disheartening story of repeated disasters. The intelligence reached London soon after our arrival at Queenstown, and the Directors were dismayed. Some did not hesitate to assert openly that the project was impracticable, declaring that it was better to sell what remained of the cable than to lose still more in what they insisted would be a fruitless attempt. They had, it was urged, tried it too often already, and what would the prudent, practical, common sense part of the world think? Think, of course,

what it never failed to say, with an emphatic and profane prefix, that it was "a bubble." The skeptical members of the company had, therefore, made up their minds that the cable should be sold. But Mr. Field insisted on still another trial, for having once entered upon the work, he was determined to prosecute it to the end. With his usual promptitude he once more set out for the British Capital, and on his arrival went at once to the Atlantic Telegraph Office. There he met the despondent members, into whom he infused new hope, spoke cheeringly of the certainty of success, alluded to the means they still had, and finally succeeded in persuading them not to abandon the enterprise until they had made one more trial. On the effect produced by Mr. Field's arguments upon the Board depended the resumption of the work. The majority of the members acceded to his appeal, and to the courageous and heroic effort which he then and there made the world is indebted for the triumph of the enterprise. But if he persuaded the majority of the Board, there was one unbeliever by whom it was so strongly opposed that he had his protest entered on the minutes of the meeting against any further trial, on the ground that it was sheer madness. His protest was placed upon the record and there it still stands over his own signature.

Mr. Field returned for the last time, as it proved, to Queenstown. July 17th the Niagara was again once more on her way to that ocean rendezvous to which they were ever returning. The Agamemnon did not leave till the following morning; but the Gorgon and the Valorous sailed before our ship.

The evening of our departure was sombre and threatening, and the dark clouds with which the heavens were overcast looked like a huge funeral pall. The aspect of the elements was certainly inauspicious, but the die was cast, and, as the result proved, fortune at last smiled upon the enterprise. The paying-out machine had, on trial, answered the highest expectations; no fault could be found in it, thanks to the skill and ingenuity of Mr. Wm. E. Everett. There still remained on the two ships about twenty-five hundred miles of cable and that allowed a fair surplus over the actual distance.

Our passage to the rendezvous was marked by such weather as is rarely if ever seen in those high northern latitudes, with the air so still for many days that it seemed as if our ship was

in the region of perpetual calms, and that the sea on whose mountainous waves we had been tossed for eight long and anxious days, had become as still as the telegraph plateau itself. Here we are, six days out, and at our appointed place, half-way between the two island outposts of America and Europe; here where there is no trace of man's work; here where no voice breaks the silence of the solitude save the harsh cry of the sea-birds. Five long and anxious days we waited for the Agamemnon; the Valorous and the Gorgon had already arrived. At last she made her appearance on the morning of the 20th of July. She had sailed a great part of the way to save coal, of which she had but three hundred tons, while of the cable there were thirteen hundred miles for the half of the distance to be traversed. The Niagara had five hundred tons of coal and about the same length of cable.

It was one o'clock when the process of splicing, already described, was completed and the signal was given to pay out the line. The wheels of the machine commenced revolving at the rate of five miles an hour and the weighted splice was soon rapidly sinking to its bed of ooze on the plateau. An hour has passed since it was lowered over the stern of the Agamemnon, and the ships are now at least five miles apart. Three o'clock has just struck and two hours have passed since we parted company; the Agamemnon is on the very verge of the horizon, and in another hour we shall be alone on the ocean with our faithful guide, the Gorgon, leading the way to the land of fogs.

Next to the paying-out machine, one of the most interesting objects connected with the work is the circle from which the cable is now descending to the depths at a speed of from six to seven miles an hour, a speed which will be increased as the vessel approaches nearer her destination. As the line is uncoiled, flake after flake, it is conducted to the paying-out machine over a series of pulleys from which it is delivered into the grooved wheels and passes on till it reaches the single wheel over the stern as it leaves the vessel. In the particular circle from which the cable is being unwound about a dozen of the most experienced coilers are stationed at regular intervals, charged with the vitally important duty of looking out for kinks, and when the last turn of each flake, or layer, is reached,

to take the bight, or bend, and lead it in safety to the cone which stands in the center of the circle. As this is the critical moment the utmost caution and vigilance is necessary, and as each flake is liable to kink when the short turns are approached, the danger attending the operation will be realized when it is known that it must be performed several hundred times on board both ships before they arrive at their respective destinations.

The next and no less important point of interest, where we obtain all the news in regard to the electrical condition of the cable, or the continuity, is the office of the electricians. To get there we have to descend to the main deck and pass on till we come to the so-called Ward Room Coil, at one side of which a small apartment had been fitted up for the electrical apparatus. It is barely large enough to accommodate half a dozen persons comfortably; but space is precious on both ships and it is economized to a miserly extent. The electrician is taking note of the signals which are passing along the whole length of the cable on board the two ships. Here are the batteries that generate the subtle current, the commutator, the electro-magnetomotor, the marine galvanometer and a number of other instruments with titles of "learned length and thundering sound." Discarding details, it is gratifying to be assured by the chief electrician, Mr. de Sauty, that the continuity is all right, and with a fervent hope that it will remain in that happy state to the termination of the voyage, we leave the little office.

Six hours have passed since the splice was made on the rendezvous and over sixty miles of cable have been submerged by both ships. It is past seven o'clock and all is going on well; but the old adage says "appearances are deceitful," and in this instance it is painfully verified, for although the paying-out continues without interruption, and the machine is doing its part of the work in splendid style, we hear with renewed feelings of dismay and despondency, that the continuity is becoming weaker every minute, and that if there be no change soon for the better, the electric current will have ceased altogether. But just as we are about to yield to despair, the glad news is announced that although two hours have elapsed since the first unfavorable indications were observed, it not only holds on,

but that it is improving every moment and in less than five minutes the joyful tidings reach every part of the Niagara that the current is coursing through the twenty-six hundred miles of cable with unabated force.

All through the night of the 29th of July the machine was in motion and the cable left the stern wheel at the rate of five and six miles an hour. And so it continued till the 1st of August, three days since the splice was lowered. The weather, which might be truly called ideal for cable laying, began to change, and although the barometer had risen to a prominent altitude, there were, according to the weather-wise, unmistakeable indications of a gale. The wind increased hourly, until it attained the magnitude of a stiff breeze; but we had no gale, and although a heavy rolling sea had set in from the northwest, it gradually became evident that there would be no storm. But the Niagara never rolled and plunged during the whole voyage as in this sea, and our fears were again aroused for the safety of the cable. To this new alarm was added still another: the old spectre of a weak and defective current haunted the harassed, unnerved and weary watchers, from the Captain's cabin all the way down to the forecastle. During three long hours this dread anxiety held possession of all on board until human endurance seemed to have reached its limit, when the suspense was at last broken by the cheering report from the electricians' office that the wavering continuity had returned in full strength and volume.

This was the last alarm, and from now on our confidence increased as the work progressed to the end. Signals continued without further interruption from ship to ship, which were now eight hundred miles apart, and these conveyed the intensely gratifying assurance that while the Agamemnon had her own troubles, she had shared our good fortune in overcoming all difficulties, and was jubilant over her success.

Three days more brought us in sight of land, and words fail to express the feelings with which we gazed on that rock-bound coast as we approached the entrance to Trinity Bay, at the terminus of which the cable was to be landed the following day, the ever-memorable 5th of August, the eighth day since we started from the rendezvous. But, as we draw nearer to our terminus and at last enter between the headlands of

Trinity Bay, a strange scene of enchantment greets our astonished sight. This land of wonders cannot surely be the barren island for which we have so earnestly longed during our anxious passage! What shore could it be that lay there in the glowing light, beautiful as an enchanted land and changeable as the figures in a keleidoscope? Now it presents the rugged aspect and bleak outline which marks nearly the whole coast range of Newfoundland, with Alpine summits that for a great portion of the year are covered with snow, or veiled in impenetrable fogs. And now it presents the form of an immense table land, level as the great western prairies. But, under the potent spell of the mirage, (for this is the necromancer whose magic power has wrought these atmospheric marvels,) scenes of bewildering variety succeed each other in rapid succession. Icebergs of all forms are around us, some white as the unstained snow; others green and translucent, sparkling in the sunlight, and as we gaze, others of gigantic proportions fall asunder, sink beneath the surface, but only to rise again in new and fantastic forms.

We are now passing up Trinity Bay, and as the shades of evening settle down upon the ocean, the mirage and all its scenes of enchantment disappear, leaving only the great headlands visible. Eighteen miles further is the landing place of the cable, the temporary Atlantic Telegraph Station on the American side as Valentia Bay is on the European side.

The steamer Porcupine, which had been dispatched from England under the command of Captain Otter, to await our arrival, now appeared in sight, and prepared to lead the way to the Bay of Bulls, where the cable was to be taken ashore the following day. Mr. Field, however, concluded not to wait and started in a small boat for the Telegraph Station, where he arrived some six or seven hours after. The occupants of the house were all asleep, but when they heard that the cable was laid they were literally bewildered. By one of these same electricians the first message was wired to nearest station connecting with St. John's, from which it was forwarded to the United States, where it was received with a welcome that came from the great heart of the nation.

At six o'clock on the historic 5th of August, 1858, a procession of six boats started from the Niagara which lay about

half a mile from the landing. The last boat in the line contained sufficient cable to reach the station. As we left the ship the men in the last boat paid out the line with their hands, an operation which was performed in less than twenty minutes; and, as the procession landed, Mr. James North, the First Lieutenant of the Niagara, presented, in due form, the end of the first ocean cable to his superior, Captain Hudson. Another procession was now formed, Captain Dayman, of the Gorgon, and Captain Otter, of the Porcupine, leading the way, holding the tarred cable in their hands, and followed by the officers of the three ships in regular procession, in accordance with their respective ranks. The cable hands of the Niagara, with a portion of the rest of the crew, formed the rear of this memorable procession. Plodding through bog and over rock, the pioneers, who had the glory of landing the first submarine line, came in sight of the Telegraph Station, where in less than half an hour the conductor was put in connection with the electrical apparatus, *and the telegraphic union of the two worlds was consummated.*

Such a consummation could not be permitted to pass without due and appropriate recognition and ceremonies. Accordingly, Captain Hudson, as the ranking officer, after an admirable address, inspired by the solemnity of the occasion, pronounced in reverential tones, that touched the hearts of his audience, a prayer of thanksgiving to Providence for the success of the great enterprise.

From Trinity Bay the Niagara set sail for St. John's, where her arrival was made the occasion of a series of popular ovations and demonstrations, including official addresses of welcome, a public dinner, and a ball in the Government Building, winding up with a regetta on Lake Quidi Vidi.

The 18th of August, after unavoidable delays, from the constant recurrence of fogs during the passage, saw the Niagara entering New York's incomparable bay, and we were home at last amid rejoicing and welcoming friends.

What though the cable had ceased to work four weeks after its submersion; the great problem had been solved and the way had been so clearly, so brightly blazoned as to make the future so safe, so prolific in results, that to-day, forty-eight years after the landing of the first submarine cable in Newfoundland, the

aggregate length of submerged lines throughout the world is, according to reliable statistics, no less than TWO HUNDRED AND TWENTY-FOUR THOUSAND SEVEN HUNDRED AND SIXTY-SEVEN MILES.

No. 223 E. 49th Street, New York, November 2nd, 1906.

MINERAL PRODUCTION OF THE UNITED STATES BY STATES.

A new feature of the 1905 number of the volume, "Mineral Resources of the United States," brought out annually by the United States Geological Survey, is a series of tables, compiled by William Taylor Thom, which shows the value by States of the mineral products of the country.

These products, so listed, include both certain raw materials and also certain derivative materials in their first marketable condition, which do not appear in the table of mineral products of the United States as a whole. For example, both pig iron and iron ores are excluded as important products entering into the commerce of certain States, and in like manner are included both pig lead and lead paints; both clay products and raw clay; both coal and its immediate derivatives, coke, gas, illuminating gas, ammonium sulphate, and coal tar; bauxite and aluminum; and also alum and aluminum sulphate. These derivatives and raw materials are here given, regardless of the consequent duplication of values, in response to a constant demand for this information thus arranged by States.

Study of these tables will afford most people more than one surprise. For example, we think of Colorado and California as our most representative mineral States, and yet, the actual value of Illinois' mineral products was far greater than that of either California or Colorado last year; more than double, in fact, the value of California's output, for although Illinois has neither silver nor gold it produces great quantities of cement, clay, coal, pig iron, stone, and zinc, which are worth much silver and gold in the world's markets.

The sums total of these State outputs for the year run as follows:

Alabama	$53,585,288	Montana	65,501,049
Alaska	16,483,759	Nebraska	1,357,846
Arizona	41,346,134	Nevada	9,873,385
Arkansas	4,470,784	New Hampshire	2,028,638
California	43,406,258	New Jersey	31,818,121
Colorado	59,280,944	New Mexico	4,382,114
Connecticut	4,098,625	New York	65,056,287
Delaware	762,944	North Carolina	2,486,063
District of Columbia	317,021	North Dakota	665,480
Florida	4,828,783	Ohio	169,203,710
Georgia	6,300,654	Oklahoma	623,333
Idaho	16,768,855	Oregon	2,441,973
Illinois	105,065,567	Pennsylvania	569,828,673
Indiana	41,781,678	Rhode Island	1,327,795

Indian Territory	5,763,346	South Carolina	2,494,457
Iowa	16,098,028	South Dakota	7,571,573
Kansas	37,971,198	Tennessee	19,641,528
Kentucky	14,871,811	Texas	13,752,346
Louisiana	6,815,430	Utah	28,447,799
Maine	5,665,804	Vermont	8,797,834
Maryland	20,048,257	Virginia	21,751,986
Massachusetts	14,024,200	Washington	8,790,544
Michigan	81,760,141	West Virginia	74,731,376
Minnesota	41,305,375	Wisconsin	16,804,611
Mississippi	874,279	Wyoming	8,657,202
Missouri	23,035,899		

The chapter of "Mineral Resources," entitled "Summary of the Mineral Production of the United States in 1905," is issued separately, in pamphlet form. Those desirous of knowing the details of State production should make request for this summary from the Director of the United States Geological Survey, Washington, D. C.

THE MINERAL PRODUCTION OF THE UNITED STATES IN 1905.

A most interesting chapter in the volume entitled "Mineral Resources of the United States, 1905," published by the United States Geological Survey, is that which contains the summary of the mineral production of the United States during that year.

In 1905, for the seventh time, the total value of our mineral production exceeded the enormous sum of $1,000,000,000. The exact figures for 1905 are $1,623,877,127, as compared with $1,360,883,554 in 1904.

As heretofore, iron and coal are the most important of our mineral products. The value of the iron in 1905 was $382,450,000; the value of the coal, $476,756,963. The fuels increased from $584,043,236 in 1904 to $602,477,217 in 1905, a gain of $18,433,981, or 3.16 per cent. Anthracite coal showed an increase in value of $2,904,980 from $138,974,020 in 1904 to $141,879,000 in 1905. The increase in value of the bituminous coal output over 1904 was $29,480,962, a combined increase in value of $32,385,941 in 1905, or 7.3 per cent.

The gain of $262,993,573 in the total value of our mineral production is due to gains in both metallic and non-metallic products, the metallic products showing an increase from $501,099,950 in 1904 to $702,453,108 in 1905, a gain of $201,353,158, and the non-metallic products showing an increase from $859,383,604 in 1904 to $921,024,019 in 1905, a gain of $61,640,415. To these products should be added estimated unspecified products, including molybdenum, bismuth, tungsten, and other mineral products, valued at $400,000, making the total mineral production for 1905 of $1,623,877,127.

Besides the usual table and summary of quantities and values of the country's mineral output by products, the volume contains this year, for the first time, a summary, in tabulated form, of the value of the mineral products by States. These tables were compiled by Mr. William Taylor Thom.

(*Read by title at the Stated Meeting held Thursday, January 24, 1907.*)

Electrical and Chemical Energy.*

By Gustaf M. Westman.

Before going into the subject we will make a comparison between the kinetic energy of gases and electrical energy.

Our formula for the kinetic energy of gases is $4\,(n^{\frac{k-1}{gk}} - 1)^2 \times \frac{c_v}{2} \times 546$, in which n is the range of pressure in atmospheres per square meter, and 546 the unit of energy in kilogram calories.

We must remember that this equation represents the centrifugal force of the ether molecule or corpuscle of the gas because the molecule itself does not take any part in the work performed.

Joule's formula for the electrical energy is $0.24\ C^2 \times R$ gram calories per second, and must be multiplied by 1000 in order to be in accord with our formula for the kinetic energy of gases. Besides we change the amperes into coulombs, whereby the time goes out of equation. For the same work performed the two equations will be equal, and consequently

$$4\,(n^{\frac{k-1}{gk}} - 1)^2 \times 546 = 240 \times \text{coulombs}^2 \times \text{resistance}.$$

We shall show later that if the resistance is chosen 2.23 the square of the centrifugal force will be equal to the square of coulombs, which explains the current as an act of the centrifugal forces of the corpuscles.

In order to create electricity it is necessary that two forces in opposite directions act on the same molecule, whereby the centrifugal force of the corpuscles in the molecule are liberated and communicated to the corpuscles in the conductor.

*Read by title.

We assume at the outset that by relieving the pressure, the corpuscles are put in rotation, which is the reverse of the molecule itself being put in rotation by pressure applied to it.

In certain galvanic cells on account of maximum of work to be performed, the metal in the electrolyte is replaced by another metal in such way that the negative radical of the electrolyte is attracted from the positive pole until the new combination is formed.

When the first metal in this way is relieved from the pressure of the negative radical, the centrifugal force of its corpuscles puts them in rapid rotation, which is communicated to the conductor between the poles when the metal is precipitated on the negative poles. The reaction between the corpuscles of the precipitated metal and the conductor constitute the current.

The same current is likewise produced by a dynamo, where the corpuscles of the surrounding gas molecules are put in rotation by closing and opening a magnetic communication, and their rotatory force communicated to the circuit.

By the attraction of the clouds towards each other, and by condensing water molecules in the clouds to water, two opposite forces work on the same molecule, whereby the centrifugal force of the corpuscles is liberated and discharged by meeting the attractive force of the earth. This produces an arc of lightning.

Flames and explosions are considered as chemical actions, notwithstanding they cannot be explained as such, because they are, in fact, electrical discharges like lightning, from which they differ in the liberation of the centrifugal force, which is here brought about through chemical attraction or pressure.

An explosion is always sudden, and it is not likely that all parts can be brought into contact in a moment, at least if they are in solid state, as in the case of gunpowder.

Many explosives are not ignited by heat, but by concussion, which shows undoubtedly that pressure liberates the centrifugal force.

The same reasoning, but in less visible degree, applies to flames.

Having shown how the electric current is generated in an electric battery and dynamo, and how the electric current is

generated and discharged in lightning, in flames, in explosives, and that the centrifugal force is liberated in all cases, we will now see when a current makes the centrifugal force visible in the corpuscles.

By subjecting minerals containing various metals to the spark of a high tension induction coil, characteristic colors are imparted to the spark by the different metals.

It is not the heat that produces these colors, but the centrifugal force, which like radio-active matter puts the corpuscles of the molecule in motion.

By association (combination) of matter, which produces pressure, the centrifugal force is always liberated and produces an arc, as can be seen in flames, if the heat is sufficient to cause the same.

By the dissociation (or the reverse of combination) accomplished by heat, one of the constituent parts must acquire centrifugal force in order to be released from its combination so as to enter into another combination.

As association or dissociation depend on the centrifugal force, the energy liberated or absorbed is a measure of it in all chemical actions.

The photograph, which depends upon dissociation by chemical action; the phonograph, which depends on mechanical action; the wireless telegraph, which depends upon magnetic action; the telephone, microphone, etc., which depend upon electrical actions, are all due to the centrifugal force, either liberated or absorbed.

In all this we consider the electric current nothing but a flow of the centrifugal force of the corpuscles, which produces the same effect as the pressure of gases.

When gases are compressed the centrifugal force is stored and reveals itself in pressure.

We measure the pressure in a straight line, notwithstanding the motion is in circles, as already has been shown in our theory for the kinetic energy of gases. It is, therefore, not different in that respect from the electric current.

Equilibrium between the attractive and centrifugal forces exist only when the molecules are not acted upon by other molecules, or affected by pressure which puts the centrifugal force in action.

When molecules expand, no matter how the centrifugal force is introduced, heat is absorbed, and when they contract centrifugal force is liberated, whereby heat is created.

The electricity is created by pressure; it moves in circles; it can produce work, and the formula for the work is identical with the formula of the kinetic energy of gases, which is produced by attraction and moves in circles. When the kinetic energy is based on the centrifugal force, how can it be otherwise than that the electricity is based on the same?

That the heat produced by a combination is just the same as liberated centrifugal force by its effort to be discharged against the ever present attractive force as resistance, seems to us to indicate that in chemical action the electricity plays such an essential part, that one cannot say where the chemical action ends and the electrical action begins. The attraction is always of electrical nature.

All molecules have a molecular volume, which depends on the centrifugal force, and is changed by combination with other elements in consequence of pressure of affinity. This affinity is in direct proportion to the electrical potential, which, therefore, must depend on the centrifugal force.

It seems to us that too little attention has been given to the centrifugal force, which plays the most important part in all phenomena coming before us, not only in matter itself but in the form it takes, either as sound, light, heat, power or electricity.

We therefore consider the electric current as an action of the centrifugal force, which puts the corpuscles of the molecule into rotation, and produces the same effect as the stored centrifugal force of gases, when either discharged or subjected to their respective resistance.

After having shown a comparison between the kinetic energy of gases and the electric current, we will go a step further and show the relation between chemical and electrical energy.

As can be understood from our theory of the electrical current, the heat evolved by chemical reaction and the heat evolved when the electrical current is discharged, rest on the same principle, namely, the attractive force or pressure. The difference is that in the electrical current the centrifugal force origi-

nates in the corpuscles and heat is produced, when the current meets attractive force or resistance, but that heat is produced directly in chemical reactions. The attraction between two bodies, which acts like pressure, causes a rotatory movement in turn, which rotatory energy puts the corpuscles in the conductor in motion, but in a chemical action causes friction and consequently heat, which stops when both parts are alike in size, when they combine with each other.

In chemical and electrical processes the heat or the current, which produces heat, when discharged, is consequently a reaction from two bodies, and it cannot be estimated how much heat is produced from each. That is shown perfectly in the many tables of substitution of one element for another by Berthelot. Alkaline and earthy molecules are exceptions, which show an even heat-difference between them when one is substituted for another.

Fl^2, Cl^2, Br^2, I^2, Cy^2 in aqueous solution when displaced one for another in combination with an alkaline or earthy molecule shows a certain difference, likewise for O, S, and Se in aqueous solution. The heat evolved in combination of the same negative elements with all other molecules does not give anything like a constant heat-difference by substitution between themselves, or by substitution of the negative radical—one for the other.

The only thing that can be estimated is the alteration of the size of each part, from which a conclusion can be drawn about the work performed by each of them.

We will first show how this can be done in chemical reactions.

Our principal energy formula for solid and liquid bodies is

$$n^{\frac{2(k-1)}{k}} \left(n^{\frac{k-1}{k}} - 1\right) \frac{c_v}{2} \times 546$$

in which n is the range of pressure in atmospheres per square meter, and equal to the product of the number of molecules per cubic meter multiplied by 22.3, thus showing how many times the molecule has been contracted in changing from its gaseous state to its liquid state at the boiling point.

If m is the number of molecules per cubic meter at boiling

point $\frac{1}{m}$ cubic meter is the volume of that molecule, and if $\frac{1}{m^2}$ square meter is the base, the molecule contains m equal layers, which we call points of that element.

The kinetic energy of gases shows itself to be inversely proportional to its heat capacity divided by 2 and as the energy of matter is directly proportional to the unit of energy the relative energy of all matter can be expressed by $\frac{2 \times 546}{c_v}$. Cal.

Heat is the reaction from converting attractive force into centrifugal force or converting linear motion into rotatory.

This can best be seen by the process of compressing gases when the attractive force is used for compression, and the centrifugal force is stored in the gases. For all chemical reactions the pressure, which causes the contraction, creates a centrifugal force, whereby heat is developed.

The heat capacity is the quantity of heat in calorics evolved per degree of temperature, which for the above formula must be at the boiling point.

Notwithstanding that the alkaline elements and the halogens contract to less than half, and that many elements contract only a few points and others not at all, we understand the energy of an element to be equal to the heat evolved when its size is reduced to one-half at its boiling point.

The more energy an element has when reduced to half its volume, the smaller is the heat capacity. On that account, and on account that $\log c_v^{\frac{k \times 1}{k}}$ is constant we assume that the product of the energy and the heat capacity at the boiling point is the same for all elements. This assumption is not substantiated by experiments, as no such determination was ever made except for Hg.

The energy of Hg^2 is 87,200 Cal., and the heat capacity at the boiling point for $Hg^2 = 12.5$.

$87{,}200 \times 12.5 = Q. \times c_v$; if Q is the energy of the element in question and c is its heat capacity at boiling point. From the energies of elements is calculated the heat capacities as follows:*

*We refer to our thermochemical data for the energies of elements.

$H^2 = 1.6$, $K^2 = 16.4$, $Na^2 = 16.4$, $Si^2 = 16.4$, $B^2 = 2.4$, $O^2 = 3.2$, $F^2 = 4.8$, $S^2 = 8.6$, $Ca = 13.3$, $Sr = 6.8$, $Ba = 6.8$, $Mg = 6.5$, $Zn = 6.5$, $Cd = 10.4$, $Hg^2 = 12.5$, $Ag^2 = 6, 8$; $C = 4.2$, $Si = 11.2$, $Al^2 = 8.7$, $Cu^2 = 10.4$, $Ni = 2.64$; $Co = 2.64$, $Fe = 6.25$, $Sn = 5.6$, $Mn = 5.5$, $Pb = 6.28$; $Au^2 = 8.5$; $N^2 = 3.2$; $O^2 = 8.5$, $As^2 = 10$, $Sb^2 = 11.8$; $Br^2 = 10.4p^2$ $Cl^2 = 8.8$; $Br^2 = 13.2$; $I^2 = 17.6$.

If we except the heat capacity for alkaline matter and the halogens, which, on account of their greater contraction. must not be counted, the most remarkable fact of the above table is that the heat capacity of H^2 decreases from 4.8 at ordinary temperature to 1.6 at the boiling point, or to one-third, and that the heat capacity of C increases three times from 1.38 to 4.2.

The heat capacity of O^2, N^2, P^2 decreases [2] and that of Ag^2 Co, Ni, Ag, $\frac{1}{2}$, while the heat capacity of Si and Ca is increased by 2, and of Cd by $1\frac{1}{2}$.

The heat capacity for the rest of the elements is about the same as at ordinary temperature, a remarkable fact for which no explanation can be given.

The volumes at the boiling point for the following elements have been found directly from the specific gravities in liquid conditions, namely, for $O^2 = 34.3$, $N^2 = 33$, $Cl^2 = 23$, $Br^2 = 18.5$, which figures are ordinarily placed at the foot of the symbol.

In many cases the number of molecules per cubic meter in the solid state is to the number of molecules per cubic meter at the boiling point as the square root of the boiling point is to the square root of the freezing point.

If the ratio of the square root of the boiling point to that of the freezing point is made the divisor of the number of molecules per cubic meter in the solid state, we will have the number of molecules per cubic meter at the boiling point.

$$K = \frac{22.5}{1.62} = 14,\ Na = \frac{42.5}{1.65} = 27,\ Hg = \frac{69}{1.61} = 43.6,$$

$$Zn = \frac{108}{1.29} = 84,\ S = \frac{64}{1.26} = 51,\ P = \frac{64}{1.34} = 48,\ Al = \frac{96}{1.31} = 70.$$

In Cd the solid volume is to the volume at boiling point di-

rectly as the boiling point is to the freezing point, namely, Cal$=\frac{76.8}{1.78}=44$.

For the other elements "m" has been found from the energy evolved in combination with 4 to 5 separate elements, when "m" and its energy are known. If we deduct from the energy evolved by such combination the energy belonging to the known element, the remainder must belong to the unknown element with the same volume number as the known element. If we perform the same operation with four or five other known elements, we have a certain volume number for each reaction, and an energy corresponding to that volume number. From all these volume numbers and corresponding energies, we can find the zero volume number for the unknown element.

When the energy of each element is to be determined from the heat evolved by combination, the volume-number plays the most important role. A negative element enters into the combination, not only with one, but with two, three, sometimes four atoms, and must under the same volume-number commence its action in combining with the whole series of positive elements, each of different size and energy. It is easily understood that only a small difference in the volume-number would be fatal for all calculations. It is therefore necessary to see the volume-number from as many sides as possible.

We mark the number of molecules per cubic meter at the bottom of each symbol and place them in the eight groups of the periodical law, with two series for each group. In this way it can be seen how the volume-number alters from one to another in this same group, and it is reasonable to believe that the periodical law has a great bearing on the sizes of the atoms, just as it has on the weights.

1.	H^2	Li^2	K^2	Na^2	Cu^2	Ag^2	
	78	28	7	13.5	40.5	40	
2.	Ca	Sr	Ba	Mg	Zn	Cd	Hg
	41	38	32	84	84	44	43.6
3.	B^2			Al^2			
	45			35			

4.	C	Si	Sn	Pb	
	72	36	54	48.5	
5.	N^2	P^2	As^2	Sb^2	Bi^2
	33	24	23	23	23
6.	O	S	Se		
	34.3	51	49		
7.	F^2	Cl^2	Br^2	I^2	
	57	23	18	13	
8.	Ni	Fe	Co	Mn	
	88	101	108	115	

In the first group the number of molecules per cubic meter of K^2, Na^2, Li^2 stands nearly as 1. : 2 : 4, and are nearly equal at Cu^2 and Ag^2.

In the second group Cd, Ca, Sr and Ba have a difference of 3 to 6, also Zn and Mg, and Hg differs from Cd only 0.4. The difference in C, Sn and Si is 18.

The second series of the fifth group are nearly equal.

In the sixth group $O^2 : S = 1\frac{1}{2}$.

Seventh group differs by 5.

Eighth group has a difference of 7, except that the difference between Ni and Fe is 13.

Most elements contract considerably by combination, but C contracts only 6, and H^2 only 3.14, and Mn, Fe, Co, Ni and B^2 do not contract but expand.

Inserting the values of "m" and c_v in the formula $\frac{2 \times 546}{c_v \times m}$ the following relative heat quantities are obtained per unit: $O^2 = 10$, $N^2 = 10.5$, $Cl^2 = 5.4$, $Br^2 = 4.6$, $I^2 = 4.8$, $S^2 = 5$, $K^2 = 9.6$, $Na^2 = .5$, $Li^2 = 2.4$, $Ba = 5$, $Sr = 4$, $Ca = 2$, $Mg = 1$, $Zn = 2$, $Cd = 2.4$, $Hg^2 = 2$, $Ag^2 = 4$, $Cu^2 = 2.6$, $Al^2 = 3.6$, $B^2 = 7$, $Mn = 1.73$, $Fe = 1.72$, $Co = 3.8$, $Ni = 4.7$, $Sn = 3.6$, $Pb = 3.6$, $Si = 2.7$, $C = 3.6$, $P^2 = 5.4$, $As^2 = 4.8$, $Sb^2 = 4$, $Bi = 4.55$ $H^2 = 8.8$, $F^2 = 4$, $Au^2 = 3.4$.

The number of atoms is twice that of the molecule. When the atoms of a molecule act against one another, the energy of

each atom is one-fourth of the energy of the molecule, but only half as much when the atoms do not act against one another.

We estimate the energy per volume-number as follows: O = 2.5, N = 2.6, Cl = 1.35, Br = 1.15, I = 1.20, Cu = 0.65, F = 1.35, H = 2.2, and for S = 2.5, As = 2, Hg = 1.

When these figures are multiplied by "m" the element is brought to half of its size and evolves as much heat as corresponds to "m" × heat evolved per volume-number.

After an element is combined, the compound has a heat capacity nearly equal to both its constituents, and we intend to show that $\frac{1092}{c_v \times m}$ is the energy per volume-number for the compound, if Cv is the heat capacity at boiling point and "m" the number of molecules per cubic meter.

H^2O; $\frac{19.3 \times 28 \times \frac{1}{2}}{1092} = 1$ Cal. Na^2O; $\frac{1092}{19.2 \times 45} = 1.25$ Cal.

Bn O; $\frac{1092}{13.5 \times 31} = 2.6$ Cal. Sr O; $\frac{1092}{11.9 \times 46} = 2$ Cal.

Ca O; $\frac{1092}{13.8 \times 58} = 1.36$ Cal. Mg O; $\frac{1092}{11.4 \times 80.5} = 1.19$ Cal.

Cu O; $\frac{1092}{13.6 \times 80} = 1$ Cal. Pb O; $\frac{1092}{11.4 \times 40.8} = 2.2$ Cal.

So^3; $\frac{1092}{10.8 \times 23} = 4.4$ Cal.

The energies per volume-number are confirmed in the determination of oxides.

If we now go to the chlorides and sulphates, we must observe that both the components act as independent bodies against each other, and therefore the equation must be changed into $\frac{\cdot 546}{c_v \times m}$.

All the energies of the following compounds are derived from their combination with H^2O.

$Sr\,Cl^2$ $\frac{546}{17.4 \times 19.3} = 1.6$ Cal.; $Ca\,Cl^2$ $\frac{546}{20.5 \times 20} = 1.33$ Cal.

$Mn\,Cl^2\ \frac{546}{19.7 \times 19.7} = 1.41$ "; $Fe^n\,Cl^2\ \frac{546}{21.6 \times 20} = 1.26$ "

$Sn\,Cl^2\ \frac{546}{23 \times 14.6} = 1.44$ "; $Mn\,O^4S\ \frac{546}{23 \times 18.2} = 1.27$ "

$Zn\,O^4S\ \frac{546}{25 \times 20.5} = 1.05$ "; $Cd\,O^4S\ \frac{546}{26 \times 22.7} = 0.9$ "

Modern electric theory states that every element contains 1000 corpuscles or electrons, which view is substantiated by Faraday's law, and if we multiply the figures given above with 1000 we arrive at the exact heat quantities.

There is, however, a difference between chemical and electrical energy, in that the former originates from the molecules or atoms, while the latter depends on the corpuscles therein.

The energy for each electron is therefore 546 Cal. divided by $\frac{c_v}{2}$ and as the current divides into two parts, one part is equal to the square root of 546, and the other the square root of 546 divided by $\frac{c_v}{2}$. To arrive at the energy for a molecule, one of the forces must be multiplied by 1000. The square root of 546 is 23.366, and if we multiply the force by 1000 it will correspond to 23,366 Cal., which figure will replace one volt of the electric current in separating one chemical equivalent from its combination.

It has been found by many experiments that 0.001118 grammes of silver are separated from its combination with a current of one coulomb, and as the chemical equivalent of silver contains 108 grammes, it will take $\frac{108}{0.001118} =$ coulombs to eleminate one univalent equivalent. Instead of gramme molecule we can use kilogram molecule, if the calories are made in kilogram calories.

Joule's formula can be written 0.24 volts $\times$ coulombs, and as Ag Cl develops 29,500 Cal. in formation $\frac{29500}{0.24 \times 96.540} = 1.27$ volts are necessary to attract the constituents to the poles,

which confirms our statement, that one volt can be replaced by 23,366 Cal.

Formerly we made a comparison between the kinetic energy of gases and the current, and will now compare the current with the energy in matter, or with our principal energy formula

$$n^{\frac{s(k-1)}{k}}\left(n^{\frac{k-1s}{k}}-1\right)\times\frac{c_v}{2}\times 546,$$

in order to show how the electrical forces stand to the natural forces.

We must select for that purpose a salt, for instance Na Cl, which has a resistance against the attractive force from the poles equal to 4.16.

If this is performed Joule's formula will be written $\frac{\text{volt x coulomb}}{\text{resistance of salt}}$ gram calories or $\frac{\text{volt x coulomb x 1000}}{\text{resistance of salt}}$ kilogram calories, in order to be in accord with our principal formula.

The resistance of the salt is $\frac{23.3 \times 2}{c_v}$, and as both formulas equalize each other when the same amount of work is performed, we have $\frac{\text{volt x coulomb x 1000 x } \frac{c_v}{2}}{23.3}$ = centrifugal force, x attractive force, x $\frac{c_v}{2}$ 546.

From this it can be seen that $\frac{\text{volt x coulombs}}{\text{centrifugal forces x attract force}}$ = 12.7.

This is very significant, because 12.7 equals 4, π which is a factor in all problems of rotatory energy, showing that the work performed is a rotatory one, and besides that the work cannot be performed by the forces belonging to the molecule. The forces must, therefore, belong to the corpuscles, which in some way have been liberated to act, and it shows undoubtedly that the current originates from the centrifugal force of the corpuscles.

After having seen how the chemical energy can be converted into electrical energy, the most important question is to find how the current is conducted, and we will first state our opinion in regard to metallic conductors.

To understand the conductivity of the current, we must go to

Joule's formula for the heat evolved by its passage through the wires. As that formula is identical with our formula for the kinetic energy of gases, we suppose that the same deductions can be drawn in both cases. We have shown that when a gas is discharged from pressure into a vacuum, the motion of the molecule is a circle.

On these premises, and because the centrifugal force cannot produce heat, we conclude that the conduction of the current consists in forcing the corpuscles in rotation in such a way that they react from one molecule to the other between the poles.

When the current is closed through an electrolyte, the opposite takes place, namely, that the rotation of the corpuscles, which begins as soon as the positive radical is released from the negative, is checked, and the corpuscles brought back to molecular conditions by the circuital lines of force which traverse the electrolyte between the poles.

The density of the current must correspond to the formation heat of the salt in the same state, as in the electrolyte, and is divided into two parts, of which one separates and conducts the constituents to the corresponding poles, and the other, its complement, which checks the rotation of the corpuscles and restores them into molecular condition.

The concentration of the electrolyte, the distance between the poles, which all can be referred to a question of distance, come under the law of magnetic fields.

We have, consequently, no doubt in making the following statement:

When the current releases the negative radical from the positive radical, which is attracted and deposited on the negative pole, the corpuscles are in rapid rotation, and in order to stop this rotation and bring the corpuscles back to molecular condition, the current from that pole is consumed, no matter if the corpuscles are from metals or hydrogen.

The attraction and consequently the power to resolve a combination, depends on the electro-motive force at the poles.

A molecule can be considered as enclosed energy under a certain pressure equal to 22.3 x m atmospheres, which pressure is controlled by the attractive force of the corpuscles in the molecule.

This pressure acts according to our formula.

When an outside attraction takes place the opposite poles of all the corpuscles are turned against this new force, whereby the pressure is released and the centrifugal force is set in action.

All elements are thereby brought to the zero-volume number, for which a certain amount of energy, different for each element, is taken. When the attractive force from outside continues more pressure and consequently more centrifugal force is created.

The radio-active substances are just opposite to carbon, not only to look at but in the characteristic property that the corpuscles of carbon have a great affinity for each other. This affinity is the real cause that carbon does not volatilize except at the highest temperatures always forming new combinations, which makes its volatilization impossible. If it were not for this reason carbon would be volatile at 110° temperature.

The radio-active substances, on the contrary, have a very small affinity for each other, and if it were not for their disintegration into new elements, their properties could well be in harmony with other earthy elements, by which the centrifugal force is superior to the attractive force.

The heat evolved by chemical action can be calculated from the specific weight of the formed compound, which gives the number of the molecules per cubic meter.

This number must be multiplied by a coefficient to find the number of molecules per cubic meter for the components.

This coefficient depends on how many atoms the compound contains, and, as a general rule for the coefficient, the number of atoms must be divided by 2.

Some compounds with O and S hold O and S as atoms, and others as molecules with two atoms, in which latter case the number of atoms of the compound must be divided by 3. The valence must also be taken into consideration when the number of atoms is determined.

When Cl^2, Br^2, I^2 are contracted to half, or respectively to 46, 36 and 26 molecules per cubic meter, the coefficient is 2, when contracted to respectively 54, 42 and 33.5 molecules per cubic meter, the coefficient is 2.5, and when contracted more the coefficient is 3.

As we intend to come back to this subject, we will not at the present go into further explanation of the coefficient.

To illustrate that the energy can be calculated from the specific weight, we take K^2Cl^2, which weighs 1940 Kilos, and contains 13.2 molecules per cubic meter, multiplying this figure by 2 gives 26.4 molecules per cubic meter for the components.

Cl^2 has consequently been contracted 3.4 molecules per cubic meter from 23 molecules per cubic meter, which it contains at the boiling point.

As 5.4 was th eenergy per molecule per cubic meter, 3.4 points makes 18.4 Cal. K^2 is contracted from 7 to 26.4 with 19.4 points at 9.5 184.5 Cal.

In the same way by using the figures for energy per point, or number of molecules per cubic meter at the boiling point, which latter are given above, the energy in forming any combination can be calculated from the specific weight of the compound if the volume coefficient has been rightly calculated.

In a simple compound, up to 7 atoms, the energy has been calculated.

As the purpose of a chemical action is to bring the components to the same size, and the number of molecules per cubic meter varies from 7 to 115, it is evident that some element must expand when the others contract to form a combination, and that the number of points contracted or expanded is different from each element.

For instance, Cl^2 evolves 3.4 points in combining with K^2, 13 points in combining with Na^2, 24 points with Li^2, and 37 points with H^2. Cl^2 evolves, therefore, eleven times more heat when it combines with H^2 than with K^2.

The electric current, which represents the heat quantity when discharged is the product of the electromotive force and current, and it is necessary to have 23,300 Cal. to form one volt, wherefore the current cannot give any better explanation as to what amount of heat each compound contributes than has been brought out with thermochemistry.

There is no reasoning in saying that when 4.38 volts represent the combination of K and Cl, that 2.38 volts are due to K and 2 volts are due to Cl, because in this special case 92,250 Cal. come from K and 9,000 from Cl, which makes 3.99 volts from K and 0.39 volts from Cl.

Latent heat brings the balance of heat into the combination.

If a flame has a temperature of 1600° C. nobody would say

that 1200° belong to the oxygen and 400° to the carbon, and just as well nobody can say that 2 volts are produced from Cl and 2.38 volts from K, when combined.

Just as the temperature is not increased when latent heat is formed,—because the operation is an act of the attractive force,—so the current is not increased by latent heat.

A similar case is by neutralization, because the increased rotatory energy remains by the molecules, and no difference in specific weight occurs.

When, on the other hand, the electrical action takes place at higher temperature, the heat quantity evolved is in inverse proportion to the heat capacity.

If the specific weight should be taken of the electrolyte and of the deposited and dissolved metals in a battery before and after the current is produced, we are convinced that the difference in specific weight would correspond to the current. The same applies to concentration cells.

Chemical and electrical energy differ from each other only in that electrical energy originates in the corpuscles and chemical energy in atoms or molecules.

METHODS OF TESTING SLATE.

Methods of testing the elasticity, absorption, fissility, and resistance of roofing slates have been in use for many years, and many more or less complete chemical analyses of slate have been published. In recent years, however, more exact methods of reaching this results have been devised. All such methods have been brought together in the bulletin (No. 275) on the slate deposits and slate industry of the United States which Mr. T. Nelson Dale of the United States Geological Survey has recently prepared.

Tests are given by Mr. Dale for determining the sonorousness, cleavability, cross feature or "scalping," character of cleavage surface, presence of lime, the color and discoloration, the presence of clay, of marcasite, of magnetite, the strength, toughness or elasticity, density or specific gravity, the porosity, hardness or abrasion, and the corrodibility of slates.

One of the most satisfactory and decisive tests of slate, in the opinion of Mr. Dale, is the microscopic analysis. A thin section of slate examined under the microscope will suffice to show the character of the cleavage, the presence of false cleavage, if any, the probable durability, or indurability of the color, as well as the presence of any mineral constituents likely to determine its other qualities. Mr. Dale quotes Merriman to the effect that chemical analyses gvie only imperfect conclusions regarding the weathering qualities of slates and do not satisfactorily explain their physical properties.

Section of Physics and Chemistry.

(Stated meeting held Thursday, November 15, 1906.)

The Inspection of Imported Food Products.

By R. E. Doolittle,

Chief of New York Laboratory, U. S. Dept. Agriculture.

The Secretary of Agriculture was authorized by Acts of Congress of March 3rd, 1903, to inspect before entry into this country all foods, drugs, beverages and condiments of foreign production or manufacture. This law was embraced in the regular appropriation Act for the Department of Agriculture for the year 1903 and with slight amendments has formed a part of all subsequent appropriation acts for that Department. Congress at its last session also included the inspection of imported foods and drugs under the General Food and Drugs Act, and when this law goes into effect January 1st, 1907, the inspection of the imported foods will be carried on under the authority of the general law rather than the appropriation act. By the terms of the Act under which the inspection is now conducted, which is the Appropriation Act for Department of Agriculture of June 30, 1906, "The Secretary of Agriculture, whenever he has reason to believe foods, drugs, beverages, condiments or ingredients of these articles, are being imported from foreign countries which are dangerous to the health of the people of the United States, or which shall be falsely labeled or branded, either as to their contents or as to their place of manufacture or production, shall make a request upon the Secretary of the Treasury for samples from original packages of such articles for inspection and analysis and the Secretary of the Treasury is authorized to open such original packages and deliver specimens to the Secretary of Agriculture for the purpose mentioned, giving notice to the owner or con-

signee of such articles, who may be present and have the right to introduce testimony; and the Secretary of the Treasury shall refuse delivery to the consignee of any such goods which the Secretary of Agriculture reports to him to have been inspected and analyzed and found to be dangerous to health or falsely labeled or branded either as to their contents or as to the place of their manufacture or production; or which are forbidden entry or to be sold, or are restricted in sale in the countries in which they are made or from which they are exported."*

As is expressed in the text of the act the inspection of imported foods covers the following items:

(1) To ascertain whether or not the products are injurious to health.

(2) To ascertain if they be falsely labeled or branded; 1st, as to contents of packages; 2nd, as to their place of manufacture or production.

(3) To ascertain if they be forbidden entry to or are restricted in sale in the country in which they are made or from which they are exported.

To provide for the execution of this inspection act the Secretary of Agriculture has held† that in the absence of contrary judicial interpretation a food product shall be deemed to be adulterated

1st. If any valuable ingredient naturally present therein has been extracted.

2nd. If a less valuable ingredient has been substituted therefor.

3rd. If it be colored, powdered or polished with intent to deceive or to make the article appear of better quality than it really is.

4th. If it be a substitute for or imitation of a genuine article and offered under the name of that article.

It is also held in the absence of contrary judicial decisions that a product shall be deemed injurious to health

1st. If any substance, with the exception of the long-used, well known condimental substances, viz.: common salt, spices,

*From Appropriation Act of U. S. Dept. of Agriculture, June 20, 1906.

†U. S. Dept. of Agric., Bureau of Chem., Circular No. 18, p. 2.

sugar (sucrose), wood smoke and vinegar, be added thereto for preserving, coloring or other purpose, which is injurious to health either as determined by actual experimental evidence or in the predominating opinion of health officers, hygienists and physiological chemists.

2nd. If a product be decomposed, filthy, decayed or in any unfit condition for human consumption.

A product is held to be misbranded

1st. If any false name or property be assigned thereto in the label directly or by implication.

2nd. If any false statement be contained in the label relating to the place of manufacture or production of the contents of the package directly or by implication.

3rd. If it be not of the nature, substance and quality commonly associated with the name under which it is sold or offered for sale.

Food products are also forbidden entry into the United States if they are of a character or kind forbidden entry in the country where they are manufactured or from which they are exported.

Both the Department of Agriculture and the Treasury Department are concerned in the execution of the imported food inspection law. The Treasury Department has possession of all imported goods and the officials of that Department, upon request from the Department of Agriculture, take and deliver all samples to the Department of Agriculture for inspection and analysis. When a product is found adulterated within the meaning of the law the Treasury Department secures the reshipment of the goods when so requested by the Department of Agriculture.

To give you a proper idea of the manner in which the inspection work is now carried on it is necessary to consider briefly certain procedures in the Customs service of the Treasury Department. In the execution of the customs law it is required that a ship coming to a port in this country from a foreign country shall make entry at the Custom House, i. e., the master must file the clearing papers from the sailing port and a manifest of the entire cargo; and it is further required that within forty-eight hours after a ship makes entry all consignees of merchandise on that vessel shall also make entry at the

Custom House, filing a copy of the consular invoice covering their respective shipments of goods. A consular invoice, as its name implies, is a list of the items of merchandise, with their foreign values, together with all items of expense, all of which is certified before the United States consular officer of the port from which the goods are exported. (Exhibit No. 1.) From this invoice the approximate duty is quickly estimated and this sum paid by the importers. I may note that after the merchandise has been appraised the invoice comes back to the liquidating officers of the Custom House and any excess duty paid is returned to the importer or if sufficient duty has not been paid this must be advanced before a release of the shipment is given. But to return to the regular order of procedure. After the importer pays the estimated duty permits are given in most shipments of general merchandise for removal from the docks of all but the Public Store cases, a bond being required for their return should they be demanded for any purpose by the Government. At least one case in every ten of all case goods is sent to the Public Stores for appraisement purposes, i. e., for comparison with the invoice and fixing of values. The invoice is sent direct from the Custom House to the Appraiser's warehouse and after proper recording reaches the examiners who appraise the merchandise. It is while the invoice is in the hands of the examiner that the inspection is made by the Department of Agriculture under the Food Inspection Act.

It, perhaps, is worthy of note to mention, at this point, that when the Inspection Law first went into effect, which was July 1, 1903, the work was all done through the Bureau of Chemistry at Washington. Arrangements were made with the Department of State whereby copies of all invoices of food products were sent direct to the Bureau by the American consular officers of the different countries. From these copies of the invoices samples were requested from the Secretary of the Treasury and these samples were forwarded to Washington by the Collector of Customs at the port where the goods were entered. The delay occasioned by the transmission of samples and correspondence so inconvenienced the importers and the customs officers that it was decided to try the plan of having laboratories at the principal ports of entry. The first port

laboratory was opened in the city of New York September 6, 1904. The success of this laboratory in facilitating the inspection work has resulted in the establishment of laboratories at five of the other ports, viz.: Boston, Philadelphia, New Orleans, Chicago and San Francisco. Shipments arriving at ports at which there are no laboratories are inspected at the Bureau of Chemistry in Washington by means of the copies of invoices sent direct by the consular invoices.

The inspection by means of the copies of invoices sent direct was not satisfactory for the working of the port laboratories for the reason that it was not complete. Often the goods arrived and were passed by the Customs officials before the Department copy of the invoice was received, and again, the consular officials often neglected to send the Department copy or it was lost in the mails; as a consequence one importer's goods were passed while another's, perhaps of the same kind, were detained. It, therefore, became necessary to devise a new system of inspection and after a thorough investigation by both Departments the present scheme of inspection of the regular invoices entered by the importer while these invoices are in the possession of the examiner of the merchandise was adopted. This is carried out as follows: The inspecting officer of the port laboratory visits, generally at certain hours of the day, the various examiners having the appraisement of food products. Here all invoices are open for his inspection; in fact, no invoice containing an item of food product is permitted to be returned by an examiner until it has been inspected by the representative of the Department of Agriculture. If, on examining an invoice, the inspector finds no item from which he desires a sample he stamps the invoice "No Sample Desired by Department of Agriculture" (Exhibit No. 2.) An invoice thus stamped may be returned or passed to another examiner without further detention. If, however, a sample is desired from some item contained on the invoice the inspector attaches to that invoice a small tag on which he indicates the marks and numbers of the particular case to be sampled, the name of the substance and the amount of the sample. Data are also taken for the record of the sample, a copy of which is filed with the Chief Clerk of the Division for checking the invoices when returned. (Exhibit Nos. 3 and 4.) When a sample has been re-

quested from an invoice the examiner at once notifies the importer that such sample will be taken and that he is requested to hold intact the remainder of the shipment until the examination is completed and he is further notified from the Department of Agriculture. (Exhibit No. 5.) It also becomes the duty of the examiner to secure and forward to the laboratory of the Department of Agriculture without delay the sample requested. (Exhibit No. 5a.) An inspector is often unable to determine by the examination of an invoice whether or not a sample will be required. This is particularly true of the inspection to determine whether or not the goods are properly labeled as to country or production or manufacture. Repeated analysis of certain brands of merchandise also informs an inspector as to their composition and it then becomes only a matter of inspection of labels to determine whether or not the goods are entitled to admission. In all such cases the inspector attaches to the invoice a detention slip. (Exhibit No. 6.) When such detention slip is attached to an invoice the inspector's attention is called to the Public Store cases indicated thereon when they are opened for appraisement by the customs examiner. In substance, the inspection work, therefore, resolves itself into the examination of all invoices containing items of food products and the examination of all Public Store cases of food products when the cases are opened for appraisement purposes. The latter examination is called the floor inspection and is made at the same time the inspector visits the examining rooms for the inspection of invoices.

The floor inspection greatly facilitates the work at the laboratory as it greatly lessens the number of samples sent there for examination. As is well known, the question of adulteration is often a question of the label. If the label correctly informs the purchaser of the contents of the package and analyses have shown a certain brand of goods to contain no substances prohibited by the statute it then becomes only a question of examination of the label which can be as conveniently and as well done on the examining floor as in the laboratory. If, on examining the cases the inspector finds the goods properly labeled he simply removes the detention tag and stamps the invoice "No Sample Desired." If, on the other hand, he

finds an article not properly labeled or one the nature of which he does not know, a sample is requested in the regular way.

In the case of goods examined on the docks, such as bulk wines, liquors, fruits, spices, etc., samples of the merchandise are requested direct from the invoices in the usual manner and are obtained by means of sample tickets forwarded by the examiner to the samplers on the wharf.

When a sample is received at the laboratory it is submitted to such examination as is necessary to determine whether or not it is prohibited under the provisions of the law. It is necessary that there be no delay in this examination for the importers often sell goods on arrival and are anxious to be permitted to dispose of their shipments. Most samples are reported within twenty-four hours after they are received. Certain products, however, require a longer time for analysis. Generally speaking, all samples are reported within forty-eight hours after they are received. If the goods are found to comply with the law the importer is notified immediately upon completion of the analysis that the examination has been completed and the shipment need not be further detained. (Exhibit No. 7.) If the goods are found to be in apparent violation of the law the importer is notified of the alleged violation and a date fixed at which evidence may be presented and the case will be taken up for final disposition. (Exhibit No. 8.) At the same time that the importer is notified of an alleged adulteration the Collector of Customs for the port is also requested to secure the actual possession of the goods and hold same for final action. (Exhibit No. 9.) A sample of the product is sent to the Chief of the Bureau of Chemistry at Washington with a copy of the analysis and such data as the Chief of the Laboratory may have concerning the shipment, importer or manufacturer. The analysis is repeated by the Washington laboratory and a report made confirming or reversing the port recommendation. These results, recommendations and all evidence submitted by the importer are carefully considered in the final decision of the case by the Chief of the port laboratory. If the goods are found to be in violation of the law the Collector of Customs for the port is requested to secure their reshipment beyond the limits of the United States. (Exhibit No. 10.) If it be found that the goods are not in violation

of the law the Collector of Customs is requested to release the shipment from further detention in so far as the Department of Agriculture is concerned.

In the enforcement of the law the Department has been very lenient with the violators. For a considerable length of time when a shipment was found to be in violation of the law but the adulterant was not positively injurious to health the shipment was released with a warning to the importer and explanations of the requirements of the Act. Afterwards permission was given to correct the labels on goods already packed by the use of supplementary labels and pasters. At the present time, except in first instances, goods that are in violation of the law are required to be shipped beyond the boundaries of the United States.

It will, perhaps, be of interest if we consider some of the products that are inspected at the port laboratories and the forms of adulteration found. At the port of New York the number of invoices of food products is so large that up to the present time it has been impossible with the force of men and laboratory space at our disposal to inspect all lines of products. To one not acquainted with the Customs service it is difficult to appreciate the volume of merchandise that passes through the port. I am informed that last month between eight and nine thousand invoices of food products were passed. Of course, many of these cover shipments of whole fruits, vegetables and similar products that require no further inspection than the stamping of the invoices. But the great majority of them cover shipments of miscellaneous products and vary from one to a dozen or many thousand cases. Each of these invoices is accompanied by a declaration of the manufacturer or shipper of the goods. This declaration gives the country where the products were grown, place where manufactured and statement of the presence or absence of preservatives, coloring matters, or other foreign substances. (Exhibit No. 11.) With this declaration on all invoices we are able even without the analysis of the products to gain some knowledge of their character. Certain lines of products, however, have been taken up and the inspection made complete in every respect. By this I mean every shipment of that line of merchandise was inspected. Samples of all sihpments were taken and subjected to thor-

ough chemical examination. After it was ascertained what brands or which manufacturer's goods were in compliance with the law further shipment were sampled only at intervals to see that no change was made in their composition. Those found not in compliance were detained in each instance until the manufacturer made the proper correction either in the character of the products or the manner of labeling as the case might be. In this manner we have covered at the port of New York the various fruit products as jellies, jams, preserves and marmalades; the canned vegetables as peas, beans, tomatoes, spinach, asparagus, etc.; the prepared meats as sausages, pate de foie gras and potted meats; sardines, ground spices, vinegar, lemon oil, olive oil and egg products.

Regarding the forms of adulteration that are practiced in these various lines of product I would say they are practically the same as are found in domestic products of the same kind. In the jellies, jams, preserves and marmalades, glucose was commonly substituted for cane sugar, coal tar dyes and cochineal were frequently used for coloring purposes and salicylic acid was very commonly present as a preservative. It always seems strange to me that manufacturers will insist that they must color their prepared fruits a bright color. I recall one instance, a shipment of canned peaches presented for entry in which the goods were colored a bright red. They were labeled red peaches. I suppose the manufacturer thought the unsophisticated Americans would believe they were getting a new variety of peach. Some fruits are even colored green with sulphate of copper. It was exceedingly difficult for some of the English and Scotch manufacturers to discontinue the use of glucose and the small amounts of salicylic acid in their jams and marmalades. They made the same claim as commonly heard from our own manufacturers that the glucose was necessary to prevent the crystallizing of the sugar. The Department did not prohibit the use of glucose but it did require that when it was used the fact should be stated on the label. As a consequence every manufacturer discontinued its use, at least in the products shipped to this country, and I have never heard any complaints for reason of the sugar crystallizing. The use of preservatives such as salicylic acid is to my mind the worst of all these forms of adulteration. Not only have experiments

proven that these preservatives are positively injurious to health but their use enables manufacturers to use products and methods of preparation that are even more dangerous to the health of the consumer than the chemicals themselves. The use of preservatives puts a premium upon filth. Their use destroys all incentive for cleanliness and scientific principles in the selection and preparation of the products. I believe it is a true statement that where you find a manufacturer of fruit preserves uses preservatives in his product you will find that his factory, apparatus or containers are not in a proper sanitary condition. I know there has been a great change in the character of the preparation of this class of products that are brought into this country since the use of preservatives was prohibited. Jars have been changed in form and scientific methods of sealing adopted, in fact the whole nature of the product altered. This is also true of the German sausages. Boric and benzoic acid were used almost universally in the canned sausages supplied to this country. And this in a way was very peculiar, for Germany has very stringent laws which prohibit the use of these preservatives in the products used in their own country. Therefore by the wording of the law, which I have already quoted to you, these goods were prohibited entry into this country. What was the result? It cost the American importer from one to two dollars a case more for the sausages, for, as one manufacturer wrote, "We have to put up the sausages in sterilized water." Outside of the use of preservatives very little adulteration has been found in the imported meat products. One or two instances of the use of potato flour have been detected. By the regulations formulated for the enforcement of the new food law which goes into effect the first of next January all shipments of meat and meat food products will have to be accompanied by a certificate of official inspection of a character to satisfy the Secretary of Agriculture that they are not dangerous to health.

In the canned vegetables another class of coloring matter and preservatives was found. As is well known, nearly all canned French peas and beans are colored with sulphate of copper. The Secretary of Agriculture has ruled that "Pending investigations that are now making, all food products colored with sulphate of copper or to which sulphate of copper

has been added for any purpose should contain upon the label a statement in English in letters not smaller than long primer caps "Colored With Sulphate of Copper," or if preferred "Prepared With Sulphate of Copper." As a result all the peas and beans, macedoine and spinach now bear a statement upon the label that they are colored (or prepared) with sulphate of copper. In the canned asparagus sulphites have been found, and practically all canned mushrooms show small amounts of sulphites due to the bleaching process to which they are submitted. Soon after the inspection work was begun at the port of New York we found that there were being entered at that port large quantities of mushrooms labeled "Champignons d'Hotel," hotel mushrooms. An examination of these goods revealed the fact that they consisted of only waste pieces, the refuse from the canneries. Such products are now labeled "Champignons, Pieces and Stems." Large quantities of canned tomatoes and tomato paste are imported into this country from Italy and salicylic acid and benzoic acid were found in many instances when the inspection of that line of products was taken up.

Another product which was largely adulterated when the inspection was first begun was olive oil. Peanut oil and sesame oil were the adulterants most commonly employed. At present I believe I am safe in saying that not an ounce of the adulterated oil is entered at the ports where laboratories are established. But this does not mean that the consumer is obtaining the unmixed oil. The oils are simply brought over separately and mixed on this side. It is not a strange thing to see on the same invoice so many barrels or tins of olive oil and so many barrels of peanut oil. I do not know of any very extensive use for peanut oil in this country except as an adulterant for olive oil. A fraud which is commonly practiced and one which at the present time is giving the Customs officials considerable difficulty is the practice of certain Greek and Italian merchants who bring over oil to which they have added the "footings" or settlings from olive oil casks. This they enter as machinery oil. The duty on edible olive oil is 40 cents a gallon, while oil fit only for manufacturing purposes is free. After the oil is received it is allowed to stand for a length of time and settle or it is filtered and then the clarified product

is mixed one-half or two-thirds with cotton seed oil and put on the market for pure olive oil. These are practices which the present import inspection law cannot stop, but when the general food law goes into effect it is expected that wherever these products enter interstate commerce we shall be able to compel them to be sold for just what they are. In connection with the oils we have also inspected the sardines and other fish packed in oil. Formerly practically all sardines were labeled "Sardines a l'huile d'olive" or "Sardines packed in olive oil." As a matter of fact we found that the oil in a great many of the shipments was peanut or sesame oil or a mixture of these oils with olive. It is claimed that in France the fish are cooked in peanut oil, and after draining, are placed in the tins and covered with olive oil. Fish cooked in peanut oil do not turn so dark is the reason advanced for the use of the peanut oil. As investigations showed this to be the actual practice the Secretary of Agriculture has for the time being allowed all shipments containing not to exceed 5% of peanut oil to be entered even if labeled "Packed in olive oil." Another deception which is practiced in the sardine trade is the selling of Belgium or Portuguese sardines for the French product. This is also true of Italian and Belgium peas and beans which are represented as the French. The Treasury law requires that every package shall be labeled in such a manner as to indicate the country of origin. But the importers succeed in putting on the name of the country in such an inconspicuous manner while all the reading matter on the tin is in French with a fancy French brand that the ordinary consumer is deceived in his purchase of the goods. I am not saying that the Portuguese sardine or the Italian beans are not as good as the same product from France. But if they are as good they need not be sold under a French label. If they are not as good, and the prices would indicate they are not, then their sale as a French product is plainly a deception. It all resolves itself to the basis of all food laws; let the label tell the truth.

A product with which we have had considerable trouble in our inspection work and one which is not commonly met with in the domestic goods is liquid eggs. Soon after the laboratory was established at the port of New York we discovered that large quantities of this liquid egg were being brought in every

month and that it was preserved with about 2% of boric acid. Liquid egg is simply broken egg with shell removed. The goods came mostly from China and I understand are the eggs of the wild fowls of that region. It was used by the large bakeries and restaurants of the cities. The importers were very shrewd in bringing in the product, which they entered as "Chemical Compound," the chemical being boric acid, I suppose. The Department soon stopped all shipments of this class of goods. Large amounts of the dried albumen are received every year and occasionally a shipment of dried yoke or dried whole egg. These, however, must be free from preservatives or they are not allowed entry. Salicylic acid and fluorides are the other preservatives which have been found in this class of products.

Regarding the other products which I have enumerated as having been subjected to inspection there is none which differs enough from the domestic product to warrant discussing it at length. Practically all of the vinegar imported is the wine vinegar of France and Germany and the malt vinegar of England. Numerous cases of substituted distilled vinegar colored with caramel and the diluted products were found, but as the importers were being defrauded we have had but little difficulty in stopping the importation of these fraudulent articles. Paprika is practically the only spice brought into this country in the ground state. As this sells on its color almost entirely we have found a great many instances of the artifically colored product, the red coal tar dyes being used. A great amount of refuse spice products is imported annually, such as exhausted ginger root from the ginger ale factories of England, pepper hulls, worm eaten nutmegs and the refuse from the paprika grinders, but I thought I had found the limit when some time ago I detected a large shipment of exhausted clove stems. I remember when in the State food inspection work a prominent spice grinder tried to convince me he could not grind his cloves without using a percentage of cloves tems. I can understand it better now. However, judging from the character of this sample, the little branches of any dead tree would have done just as well.

In my discussion of the adulterated products you will probably wonder why I have not taken up the subject of wines and

liquors, which form a great bulk of our imports. I have not discussed these products for the reason that I am not as yet prepared to do so. We have done very little work along these lines at the port of New York, practically none of real inspection. Considerable research work has been done by the Department and some day we will be prepared to give you a whole evening's discussion of this important subject. I may say in passing that the non-alcoholic beverages, as ginger ales, sarsaparilla and the various fruit juices have been thoroughly inspected, and while they formerly were in many cases preserved with salicylic acid, benzoic acid, or sulphurous acid, these preservatives are now seldom used in any of these products with the exception of limejuice. Most limejuices contain sulphurous acid and this fact is stated on the label.

The results obtained by the enforcement of the inspection act offer much encouragement to all interested in the securing of pure food products. There has been a marked change in the character of all foods imported into this country. Many products that formerly contained preservatives and coloring matters are now free from these added substances. That to the consuming public means much more than danger that might arise from the consumption of the products containing these ingredients. It means that the consumer may know that he is getting just what he calls for; and it means that the manufacturer has produced his product from sound healthy substances in a clean scientific manner and stored them in clean properly sealed containers. As the manager of a large manufacturing concern told me some time ago, "We have got to change our business and put it on a scientific basis. We have always used preservatives for the reason that it was the easiest way. It really is the lazy man's method." And so it is. I, for one, do not believe that what we are to eat can be too carefully selected or too carefully prepared.

It is encouraging to those interested in the enforcement of the law to note the attitude that was assumed by the importers from the very beginning. Of course, there are among the importers at the different ports, as in all other branches of business, some who can only construe the law as enacted particularly to destroy their business and who will not make a change in their products or a correction in their labels except as they

are absolutely compelled to do so. Their sole object seems to be to see how much they can violate the spirit of the law and yet succeed in entering their goods under the strict interpretation of the Act. But the majority of the importers have favored the law and have supported the officials in its enforcement. With them, to correct a violation it has only been necessary to explain what the violation was and then give time to get the matter corrected on the other side. Perhaps the greatest difficulty, at least one of the worst, has been to get the manufacturers on the other side to understand our requirements and to make the change. These manufacturers are for the most part people speaking another language and separated from us by the broad space of the Atlantic. They have produced their goods in the same manner for years and they cannot understand why we should now demand a change. Another difficulty has been the fact that certain lines of products are put up when there is abundance of that product and then the goods are kept on hand for years. This is true of such products as sardines. When there is a good run of sardines the packers put up all they can catch, for there is no telling how long it will be before there is another catch. One importer told me the other day he had tins for 10,000 cases of sardines held over from last year and so far this year he had packed 34 cases. These are difficulties we have to meet and the Department always takes all such matters into consideration in deciding each individual violation. Our present law is far from perfect, but many of its defects are corrected in the Food and Drugs Act which goes into effect January 1st, 1907; and from the assistance that will accrue from a law governing the domestic as well as the imported goods it is expected much better results will be obtained from the enforcement of the law in the future. The port inspection work has but nicely begun. There are many and important lines of products not subjected to proper inspection. Complaints are constantly being received concerning the adulteration of certain products. The truth of these must be investigated before the real inspection of those products can be begun. In fact, there is always a certain amount of investigation to be done before any new line of inspection can be taken up. The work of the port laboratory is by no means confined to the analysis of samples from

the shipments inspected. Studies on the composition of products, detection of adulteration and methods of analysis must be kept constantly under way. However, a great change for the better has already been accomplished on the products inspected and with the advent of the new law and the increase contemplated in the inspection force it is expected greater and better results will accompany the work in the future.

PRODUCTION OF COAL IN CALIFORNIA DURING 1905.

The total production of coal in California during 1905 was 77,050 short tons, valued at $382,725. These figures are taken from the report of Mr. E. W. Parker of the United States Geological Survey.

The principal feature of interest connected with the production of coal in California has been the apparently successful efforts to utilize the lignite or sub-bituminous coals produced in the State in the manufacture of briquettes. During 1905 there were four of these plants in operation. One, at Stockton, was operated by the San Francisco and San Joaquin Coal Company, which used the lignite or sub-bituminous coal produced at the Tesla mine owned by the same company. Unfortunately, this plant was entirely destroyed by fire in November, 1905, and the plans for its rebuilding, this time at San Francisco, have been interrupted by the earthquake and fire which nearly destroyed that city in April of the present year. Another plant constructed in Oakland by the Western Fuel Company upon designs prepared by Mr. Robert Schorr, of San Francisco, was put in operation during the latter part of the year. The third plant, a small one, owned by the Ajax Coal Company, of San Francisco, was in operation during most of the year, and the fourth, which was built at Antioch, was not completed until the latter part of the year. All of these plants were constructed for the purpose of using the California lignites or sub-bituminous coals, sometimes with and sometimes without a mixture of "Wellington" and other bituminous screenings obtained at the coal yards, and using asphaltic pitch as a binder. This pitch is obtained as a residue from California crude petroleum which when properly distilled yields a pitch possessing excellent binding qualities.

Mining and Metallurgical Section.

(Read by title at the Stated Meeting held Thursday, January 31, 1907.)

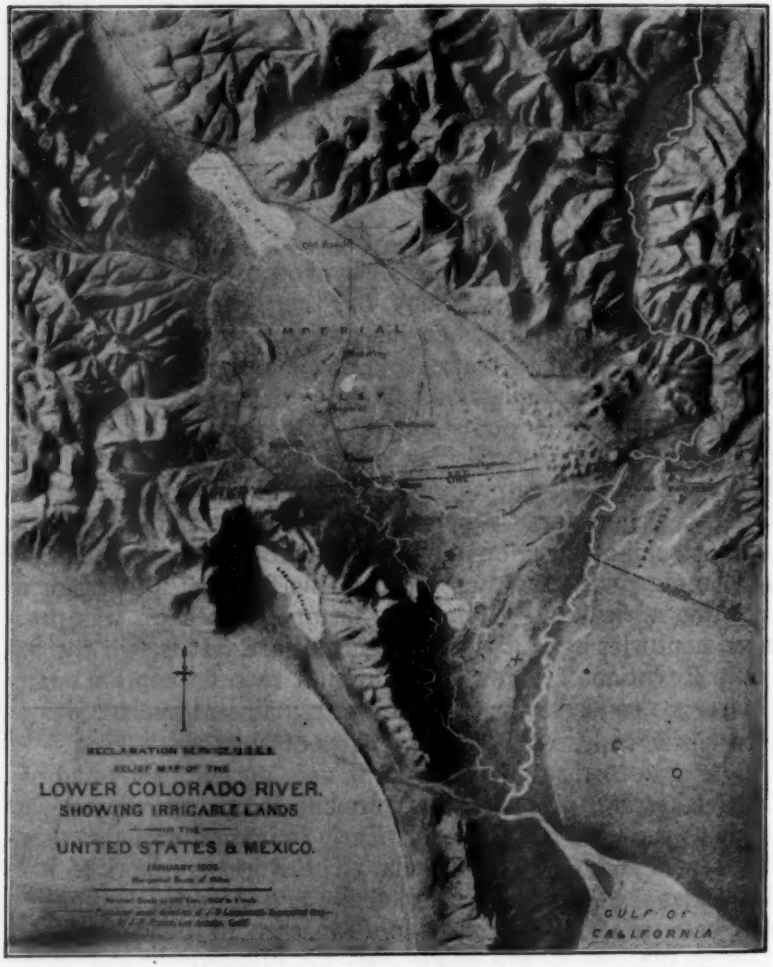
Irrigation and the Government Irrigation Project at Yuma.

Prof. Oscar C. S. Carter.

Primitive man was doubtless carnivorous much more so at least than is his brother to-day, but there came a time at last in the history of man when his attention was drawn to the vegetable world as a source of food supply; just when or where this was is a question. There is no doubt that environment influenced the food supply of early man as it does to-day his more or less civilized brother. Environment makes the Esquimaux a flesh-eater and the Indian of the tropics more or less of a vegetarian. When man first began to till the soil in arid or semi-arid regions he learned that water was necessary to plant growth and thus received his first natural lesson in scientific agriculture. Irrigation, history teaches us, was practiced centuries ago; it is a very ancient art. It is said the ancient Egyptian, Hebrew and Oriental records contain many references to irrigation. There are remains of ancient irrigation works in Europe, Asia and parts of Northern Africa.

The art of irrigation in Egypt is very ancient; they had extensive systems of lakes, reservoirs and canals, so it is said, as early as the time of Sesostris. Early irrigation was also practiced in Persia, China and India. The Romans practiced it in Italy and the Moors in Spain, Sicily and Algeria. Irrigation has been practiced recently in France to destroy the insect pest phylloxera of the grape vine by submerging the roots. In the arid regions of the Southwest near the Gila, Salt and Verde Rivers, in Arizona, near streams in New Mexico, and near the Rio Virgen in Nevada, are found ancient irrigation ditches, some of which are of great length. These were used

by the aborigines centuries before the time of Columbus. Some of these show considerable engineering skill in their construction, at least good judgment in the selection of sites and great patience in their construction, particularly where



they are cut through solid rock. In the 13th Annual Report of the Bureau of Ethnology is an article by Cosmos Mindeleff on Aboriginal Remains in Verde Valley, Arizona. On page 194 he states: "Irrigation ditches and horticultural works

were found in this region. Fine examples of irrigating ditches were found at the extreme northern and extreme southern limits of the region treated and there is a fair presumption that other examples occur in the intermediate country. These works did not reach the magnitude of those found in the Gila and Salt River Valleys, perhaps, partly for the reason that the great fall of the Verde River renders only short ditches necessary to bring the water out over the terraces." Page 238 he states: "One of the finest examples of an aboriginal irrigating ditch that has come under the writer's notice occurs about two miles below the mouth of Limestone Creek, on the opposite or eastern side of the river. At this point there is a large area of fertile bottom land, now occupied by some half dozen ranches, known locally as the Lower Verde Settlement. The ditch extends across the northern and western part of this area. Plate XXXIV shows a portion of this ditch at a point about one-eighth of a mile east of the river. Here the ditch is marked by a very shallow trough in the grass-covered bottom, bounded on either side by a low ridge of earth and pebbles. Plate XXXV shows same ditch at a point about one-eighth of a mile above the last, where it was necessary to cut through a low ridge. North of this point the ditch cannot be traced, but here it is about forty feet above the river and about ten feet above a modern (American) ditch. It is probable that the water was taken out of the river about 2 miles above this place, but the ditch was run on the sloping side of the mesa which has been recently washed out." "On the southern side of Clear Creek about a mile above its mouth there are, near the ancient village ruin, extensive works covering a large area of the terrace or river beach, for a distance of two miles east and west along the creek and perhaps a half a mile north and south there are traces of former works pertaining to horticulture, including irrigating ditches, reservoirs, farming outlooks," etc.

In South America there are aqueducts which are used to carry water for miles for irrigation and other purposes. They were constructed by the early Indians. Enough has been said to draw attention to the fact at least that irrigation is not new in this country. Mr. E. A. Beals, Official Forecaster of Weather Bureau, states in Year Book Agriculture, 1902, that "Excluding the rice-irrigation system of China, Japan and

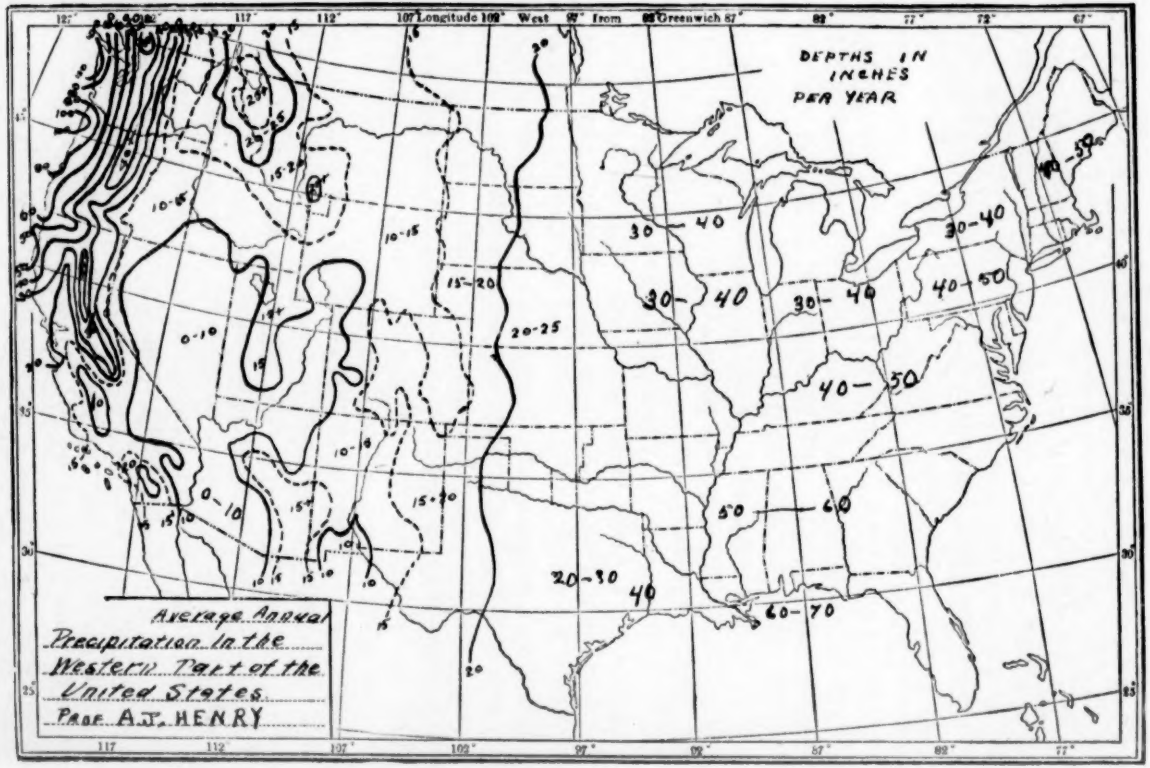
S. E. Asia, there are some fifty or more millions of acres of irrigated land in the world, and of this great area fully one-half is located in countries having a humid or semi-humid climate with an annual rainfall above twenty inches. The really arid lands are confined to scattered sections in the western half of the United States, Argentina and in the valley of the Nile below Assuan, some 500 miles from Mediterranean Sea.

IRRIGATION IN INDIA.

"The most extensive system of irrigation is in India where at least 25,000,000 out of a total cultivated area of 144,000,000 acres are irrigated. The principal canals are in the Ganges and Indus valleys, but they are found in nearly every province of the country. Besides canals built under the direction of the government thousands of small reservoirs are distributed throughout the empire. The crops raised from this water support at least 20,000,000 people. The melting of snows on the Himalayas during the hot months of March, April and May furnish water to the canals in Northern India. The rainfall is unevenly distributed, decreasing rapidly from 115 inches near the Himalaya foothills to six inches in the upper Sind province, less than 350 miles away. The greatest known rainfall in the world occurs on the southern slope of the Himalaya Mountains about 200 miles back from the Bay of Bengal. The rainfall at an elevation of 4,455 feet averages 474 inches yearly, nearly all of which falls during the five months from May to September, and as high as forty inches have been measured in a single day. On the Deccan plateau the rainfall is only twenty inches per year.

IRRIGATION IN EGYPT.

"The lower valley of the Nile, including its delta, comprise another great irrigation system with over 6,000,000 acres under cultivation. Egypt is wholly different from India as far as rainfall is concerned, being so arid that dry farming is impossible. The irrigated area begins at Assuan, about 500 miles from the Mediterranean Sea. The valley above the delta is


DEPTHS IN INCHES PER YEAR
Average Annual Precipitation in the Western Part of the United States
Prof. A.J. HENRY

narrow with a tillable breadth averaging less than nine miles. At Alexandria the annual rainfall is 8.8 inches. The annual amount at Cairo is 1.3 inches. As far as crops are concerned the annual rainfall in the irrigated sections of Egypt might as well be ignored. The waters of the Nile are supplied by heavy rains in equatorial Africa near Lake Victoria, Lake Albert and Lake Edward. Here the rainfall is eighty inches per year. These reservoirs keep the Nile from running dry through the long stretch of desert, as it would probably go dry otherwise before reaching the sea. The dam just completed at Assuan has a storage capacity of over 30,000,000,000 cubic feet. It is built of granite and is seventy feet high, twenty-three feet wide at the top, eighty-two feet wide at the bottom, and one and one-fourth miles long. It will regulate the supply of water and natural flow, which is too high during three months of the year and too low during the remaining nine months.

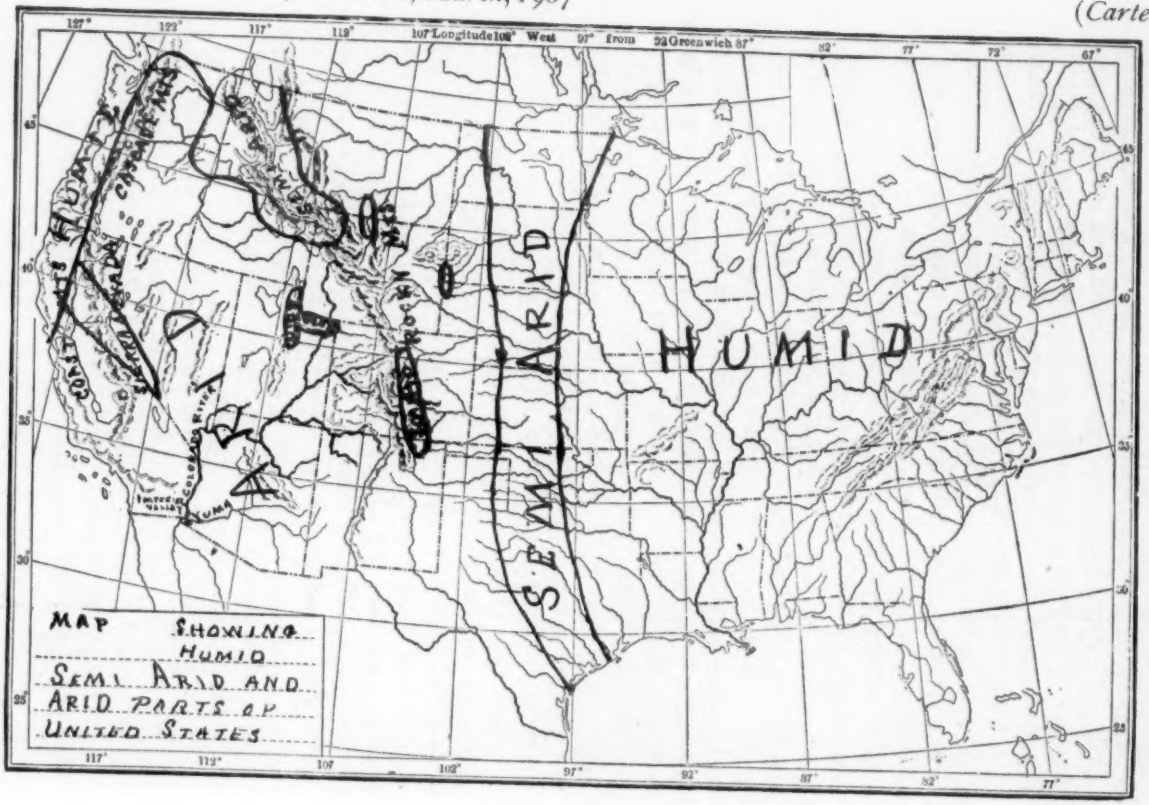
"Italy has irrigated since the time of the Romans and has 4,715,000 acres under irrigation. The rainfall varies from twenty to thirty inches per year. Spain has about 5,000,000 acres under irrigation. On the north coast the rainfall is heavy, over fifty inches per year. Near Madrid the rainfall is seventeen and one-half inches and it is less farther south. France has about 5,800,000 acres under irrigation. Near the English Channel the rainfall is forty inches. At Paris, twenty-two inches. In Southern France, about twenty-five inches. The summers are dry. In Australia little has been done for irrigation, but much has been planned. The rainfall is slight and droughts are frequent. The last three years have been droughty and it is reported that out of a total of 120,000.000 sheep at least 40,000,000 have died on account of drying up of the pastures. The rainfall for the continent of Australia is about twenty-one inches. He states the small rainfall is due to the fringe of mountainss skirting the continent, which are not high enough to collect snow, and therefore it will never be possible to irrigate much land even if all the water be utilized.

"In South America irrigation is confined principally to Argentina; the rainfall varies from three or forty inches per year. In the country of the Incas before the Conquest irrigation was practiced much more extensively than it is to-day."

His above brief extracts on irrigation in India, Egypt,

Europe and Australia are quoted because they will help us by comparison to understand better the conditions as they exist in the United States as regards rainfall and other climatic changes and also the areas under irrigation and to be irrigated. That portion of the United States east of the 100th meridian has a humid climate. The 100th meridian passes through about the middle of the Dakotas, Nebraska, Kansas, Oklahoma and Texas. The rainfall east of the 100th meridian varies considerably. In the Southern States it varies from fifty to seventy inches per year. The southern parts of the States that border on the Gulf of Mexico have a rainfall of seventy inches. The Middle States have a rainfall of from thirty to fifty inches per year and in the New England States the rainfall varies from forty to fifty inches per year. The States that border on the great lakes have a rainfall of from thirty to forty inches, so have Iowa and Missouri, but the rainfall decreases as we go farther west, and the eastern parts of those States through which the 100th meridian passes have a rainfall of from twenty to thirty inches. Between the 100th meridian and the country east of the foothills of the Rockies, roughly speaking, there is a stretch of country which might be called semi-arid. It takes in Western Kansas, Nebraska and Oklahoma and parts of the Dakotas. West of the semi-arid region the United States is arid except Northern California, Western Oregon and a large part of Washington. We might say in a general way that the United States is mostly an arid region between the 100th meridian and the Pacific Ocean. The author would like a classification somewhat as follows: An arid country is one in which the rainfall is from two to fifteen inches per year, and in a semi-arid country the rainfall varies from fifteen to twenty-five inches.

The able Chief of the Reclamation Service says that in a general way it may be said that arid regions are those where the average rainfall is twenty inches or less. According to this the arid regions of the United States include more than two-fifths of the entire area. He says: "As a matter of fact, however, a great part of the countries of the Old World have less than twenty inches annual rainfall and therefore according to our standards must be considered arid. The civilization of former times, however, grew up in those arid regions and we


HUMID
SEMI ARID
ARID
MAP SHOWING HUMID SEMI ARID AND ARID PARTS OF UNITED STATES

cannot fully appreciate the writings of the ancients and the true meaning of many familiar phrases handed down to us without bearing in mind the fact that the writers lived in an arid climate where agriculture was successful only through irrigation."

We would like, however, a distinction made between an absolute desert where almost no verdure grows and the rainfall is only say three inches, and a section of country where the rainfall is eighteen inches and verdure is abundant, providing of course the rainfall comes at a time of the year when it will do some good. In considering the rainfall of a country we must know whether the rain falls at the time of year when the growing crops can utilize it. A country may have a considerable rainfall, but if it don't come at the time of year when the crops need it, it don't avail much. Of the 3,000,000 square miles of land in the United States, excluding Alaska and the Islands, about 1,300,000 are arid. The rainfall throughout the arid region varies greatly. In Nevada, Western Utah, Southern Arizona and Southeastern California the rainfall is so slight that it varies only from two to ten inches per year. Parts of these sections are almost absolute deserts. New Mexico, Colorado, Wyoming, Montana and Idaho have a higher rainfall, varying from ten to twenty inches. These are the States through which the Rocky Mountains pass. The mountains are always great conservators of moisture and the rainfall is always more abundant in an arid region where the mountains are high enough to condense the moisture by the cold of elevation than is the rainfall in the plains below. It is this moisture which falls as snow and rain on the mountains and vicinity which feeds the streams that furnish the water for irrigation in the arid West. In fact most of the streams on which the irrigation projects depend have their source in the Sierras or Rockies.

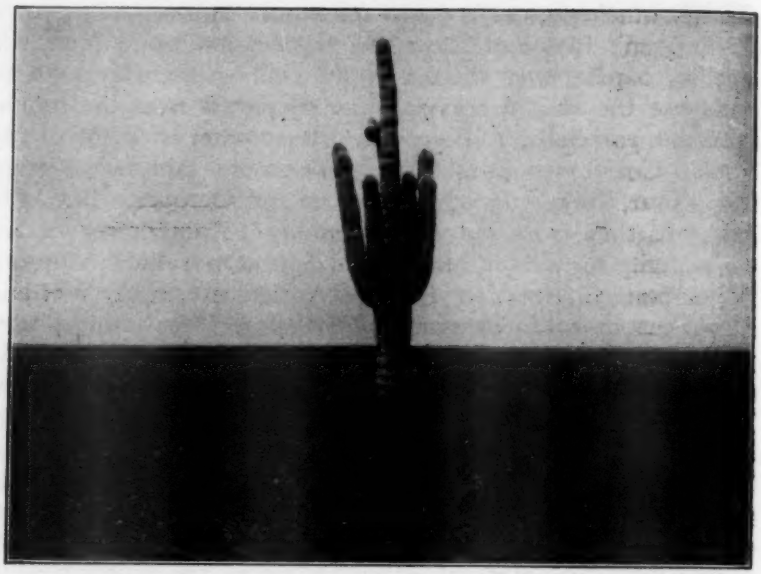
Why have we such an abundant rainfall in Western Washington, Oregon and Northwest California and such a deficient precipitation in the arid region between the Sierra Nevada Mountains and the Rockies? The reason is plain. It is not due to the proximity of the warm Japanese current, but there is a continual procession of high pressure and low pressure atmospheric areas across the United States from west to

east. These are the highs and lows of the weather map and are known as anti-cyclonic and cyclonic areas. They have nothing whatever to do with tornados, which are storms of very narrow path but exceedingly great velocity, although they are sometimes confused. In the anti-cyclonic or high pressure area the barometer is high and the cold air is coming down from above just as if through a gigantic funnel and spreads out in all directions with a spiral motion. The diameter of the area may be 1000 miles or over and three or four miles high. In the cyclonic area the barometer is low. It is a low pressure area and the warmer air is rising and the air comes in from all sides to take its place with a whirling motion. You might say the high pressure area pushes the low pressure area ahead of it across the United States. The Weather Bureau, in order to make it plain to the public, have likened them to a series of atmospheric waves traveling across the continent. The high pressure areas might represent the crest of the waves and the low pressure areas the trough. This brief explanation is inserted here because twenty years or more ago the weather was not taught in the public schools, and the average man if he can interpret a weather map carefully has been obliged to give the subject considerable study during his leisure moments. These high pressure areas start in the Pacific and push the air eastward, and as the warm vapor-laden air ascends the Coast Range of mountains it is chilled by the cold of elevation, and Western Washington and Idaho and some of the finest forest areas in the United States have a rainfall of over 100 inches per year. When these same winds cross the Cascade Range or the Sierra Nevada Mountains to the westward they part with more of their moisture either as rain or snow, so that by the time they reach the eastern slope of these mountains the winds are dry winds and don't contain enough moisture for abundant rainfall. Hence Oregon east of the Cascade Mountains is a sage brush and in places a lava desert due to deficient rainfall, while Western Oregon is a magnificent forested area. The principal reason then for the aridity of the West is; the winds have parted with their moisture to the Coast, Cascade and Sierra Nevada and Sierra Madre Mountains.

In the hottest summer months the mountains like the Coast

Range, which are only of average elevation, become warmed by the sun's rays and allow the vapor-laden winds from the Pacific to pass over them without chilling them enough to condense the moisture as rain; so they pass over the mountains, no rain falls, and we have the summer drought of the Pacific Coast. In Southern California no rain falls during May, June, July, August, September and October. But little rain falls then from May to November. Another reason for the scarcity of rains in Middle and Southern California during the summer is (See Year Book of Agriculture, 1902, Wet and Dry Seasons in California, by McAdie,) "few atmospheric pressure areas or disturbances pass eastward from the Pacific over Middle and Southern California during the summer. There seems to be an area of permanent high pressure over the ocean unfavorable for rain bearing winds on the Pacific Coast. During the winter months an area of permanent low pressure overlies the Pacific, resulting in an air circulation such that south, southeast and southwest winds prevail. During this period numerous atmospheric disturbances are experienced in the Northern Pacific and these in their eastern passage cross the coast at any latitude from Sitka to San Francisco, the larger number passing inland north of 45th parallel. The rain for the year falls practically in the months of November, December, January, February and March. Showers in April and early part of May bring the growing crops to fruition. When little rain falls in December, January or February, the outlook is poor for the crops in California."

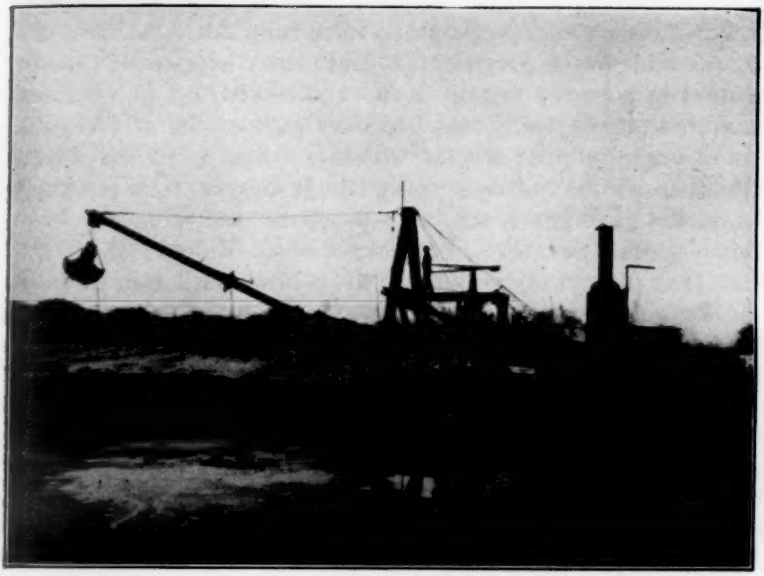
Leaving California let us consider the arid region as a whole and we will find that there are other reasons to account for the aridity. The principal reason is that conditions are not favorable for the precipitation of moisture in certain desert divisions of the arid region even if the air had moisture enough to produce copious showers. Where there are high mountains in the arid regions the rainfall is much more abundant because as the winds ascend the slopes the air expands and hence its capacity for moisture decreases; then again it is chilled by the cold of elevation. It gets about one degree colder on an average for every 300 feet you ascend a mountain. The expansion and cold serve to condense the moisture in the air and it falls as rain or snow. So we see that in parts of the arid region the



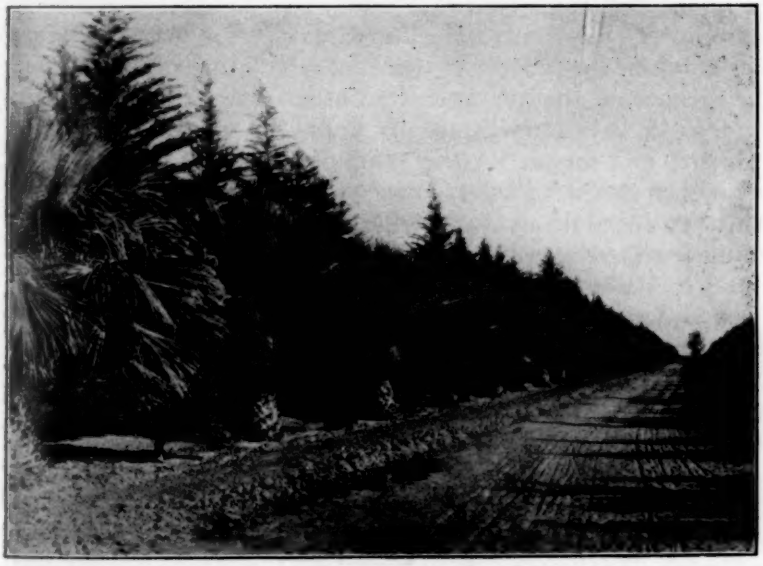
What irrigation will do in southern Arizona deserts. An unusual sight—the giant cactus cereus giganteus or (suguarro of the Mexicans) 40 feet high, growing in a field of alfalfa. This is not in the Yuma region, but in the Salt River Valley.

Laguna dam site

(*Carter*)



Steam dredger at work, Laguna dam



A driveway on irrigated land near Yuma, Arizona

air may have enough moisture to form rain, but conditions are not favorable for its precipitation and it may happen that heavy showers in a humid region were condensed or precipitated from air that originally traveled over part of the arid region. For example, warm, dry air which is rising from the desert will not condense moisture in the clouds above. The tendency is just the reverse; it tends to dissipate the clouds. Prof. Henry states, (See U. S. Weather Bureau Bulletin D, 1897): "Tables of annual precipitation tell us how much rain or snow falls during the course of the year, but they afford no indication as to whether the rain comes when it will be of the greatest service to agriculture or whether it falls after the time of maturity of the staple crops. The distribution of precipitation throughout the year is fairly uniform in the States along the middle Atlantic, in New England, in the Ohio Valley and along the borders of the Great Lakes. It is strongly concentrated in the summer months upon the Great Plains. On the other hand it shows a pronounced maximum during the winter season in the Great Basin (Nevada), where summer rains are most needed. At Winnemucca, near the center of the Great Basin, the midwinter (January) fall is nearly twelve times that of the midsummer (July) fall, while the Great Plains show a difference between the records of these months in the ratio of about five to one, on the average, the other way. For example, Garden, in Western Kansas, is upon the High Plains; the record is 17.4 inches for the year, of which 14.1 inches are credited to the six months from April to September. It is evident then that rain water in order to be of much benefit must fall during the time of year when the crops are growing. The winter rainfall is not entirely lost, however, as it keeps the soil moist and sinks below the surface to the ground water; then again evaporation is less during winter when the air is cold. In order to conduct agriculture successfully and raise fair crops at least twenty inches of rain per year are required. It may be a little less will suffice if it falls at particular favorable times, but when the rainfall is less than twenty inches per year we cannot raise abundant crops without irrigation. Even trees require for successful growth from twenty to twenty-five inches per year. One curious and interesting fact about climate and rainfall is that on the barren staked plains of Texas (Llano

Estacado) that are so dry that agriculture is almost impossible, the rainfall is as great as in the center of the wheat belt in Dakota. For example an eighteen year record at Amarillo on the staked plains in the Panhandle of Texas shows an annual rainfall of 21.94 inches; this is a grazing region, not agricultural. Yet in the center of the great wheat belt in Dakota at St. Vincent the rainfall is but 19.5. (See 21st U. S. Geological Survey Report, Part IV, page 659.) But this is explained by the fact that the hot dry south winds of Texas take up moisture like a sponge. The days are hotter, the rains spasmodic, so that the water evaporates quickly and does not sink into the soil freely enough. The facts given in this article about rainfall are necessary in a discussion pertaining to irrigation. You cannot separate rainfall and irrigation. The U. S. Geological Survey Reclamation Service state:

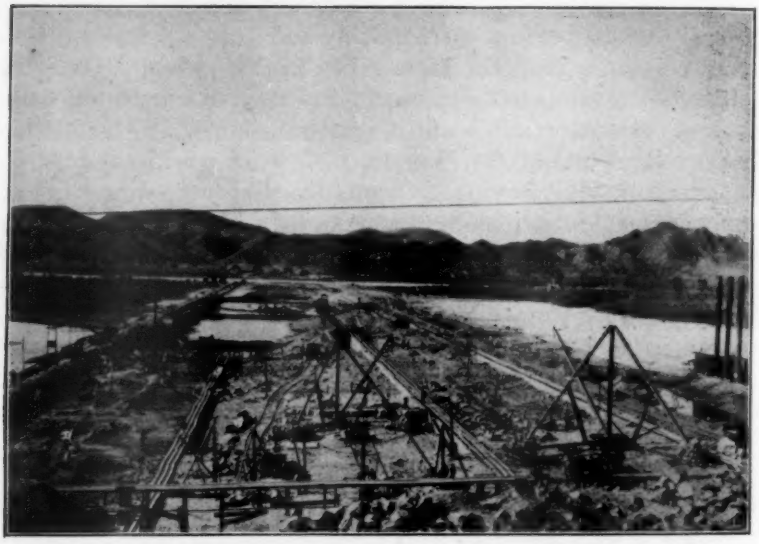
"The following brief statement regarding irrigation projects under consideration and construction by the U. S. Reclamation Service and concerning irrigable lands in public and private ownership, which will eventually be reclaimed by means of proposed system, is published in circular form for convenience in answering inquiries and for the information of the public generally."

Their statement about the Yuma Project reads as follows:

CALIFORNIA: YUMA PROJECT.

"This project contemplates diversion of the waters of Colorado River by means of proposed Laguna dam and sluiceways, about ten miles northeast of Yuma, Arizona, into two canals, one on each side of the river. In Arizona these canals will irrigate all the bottom lands of Colorado and Gila Rivers between the Laguna Dam and the Mexican boundary (an area of 84,000 acres in round numbers), and in California the bottom lands in the Yuma Indian Reservation (an area of 17,000 acres), all tributary to the Southern Pacific Railroad. Plans also contemplate the construction of a complete system of levees to protect the bottom lands from overflow, and a pumping system to remove the surplus water from the low-lying areas. Lands under this project have been withdrawn under the provisions of the reclamation act of June 17th, 1902, from

all forms of entry except by homestead. The mesa lands have been withdrawn from all forms of entry. Under the provisions of this act an individual holding may not exceed 160 acres. Definite decision has not been reached as to the farm-unit area, but it will probably not exceed forty acres to each entryman. The method by which the lands of the Yuma Reservation will be disposed of to settlers has not yet been announced. It is probable, however, that the reservation will be thrown open upon the completion of the irrigation works. The cost of



Laguna dam, 4780 feet long. General view of dam taken from above Arizona sluiceway

the works will be assessed proportionately upon each acre of land reclaimed, to be paid by settlers in ten annual installments without interest. The only additional charge will be for maintenance. The distribution of water, collection of payments, maintenance charges, etc., will be looked after by the Yuma County Water Users' Association, M. Winsor, President, at Yuma, Arizona. The members of this Association are the landowners of the district to be affected. Printed matter and information of a local character regarding the section may be had upon application to Association headquarters, at Yuma, Arizona. On July 6th, 1905, a contract was awarded to J. G.

White & Co., New York, for the construction of the Laguna dam and sluiceways. Excavation is being carried on and other preliminary plans are under way with a view to the construction of the dam. On September 13, 1905, a contract was awarded for the construction of Yuma dikes on which actual work is now under way."

THE COLORADO RIVER.

The Colorado River is the great river of the arid southwest. In an arid region rivers are scarce and generally of small volume on account of deficient rainfall and rapid evaporation, but the Colorado is an exception. One branch of the Colorado River, the Grand River, rises in the Rocky Mountains in the highest peaks of the Park Range in Colorado west of Long's Peak, where it is fed by Alpine lakes and hundreds of brooks formed by the melting of snow. The other branch of the Colorado, the Green River, rises just south of Yellowstone Park, in Wyoming, near Fremont's Peak, on Wind River Mountains, at an elevation of 12,000 feet. These two rivers unite in Utah and form the Colorado, which flows southwest 200 miles, then west for 150 miles, then south 300 miles into the Gulf of California. After leaving Utah it flows through the Grand Cañon in Arizona for a distance of 218 miles. This stupendous cañon is from 4000 to 6500 feet deep and from five to thirteen miles across and is the greatest scenic wonder in the world. The length of this river is 2000 miles. In Utah and Northern Arizona it flows through the plateau country which is from 4000 to 8000 feet above tide. After leaving the Grand Cañon below the mouth of the cañon the river forms the boundary between Arizona and California and flows through a region as absolute desert as the Sahara, almost rainless, and but a few feet above sea level. Near the Gulf its flood plain is ten or more miles in width. If you call the Green River the source of the Colorado and the Grand a tributary, then it has but four principal tributaries, the Grand, San Juan, Colorado Chiquito and Gila, and these are all on the eastern side in marked contrast with hundreds of tributaries on each side of the Mississippi, but we must remember the Colorado flows through an arid region the greater part of its course where the rain fall varies from two to fifteen

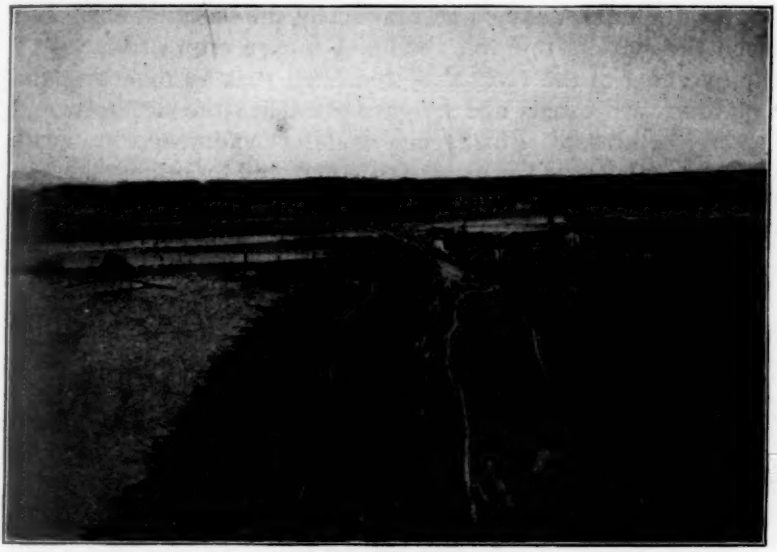
inches. It is the melting of the snows and the rains on the mountain tops which furnish most of the water, but they told me at the Grand Cañon that the river would sometimes rise sixty feet in a night after the cloudbursts in the plateau region, and many of us know what cloudbursts mean in the plateau region. Streams of liquid mud six feet deep will flow across the desert which in a few hours will be as dry as punk. The Colorado River drains an area much larger than the New England and Middle States together, an area of over 200,000 square miles, and several writers have called it the American Nile. They have some features in common. The Nile also flows through an arid region and it flows 1000 miles without receiving a branch; it has a flood plain from five to fifteen miles wide. The Nile flows north from Lake Victoria, Nyanza, and the lake basins near the source of the Nile have breakings or faultings of the earth's crust like we see in the plateau region in Arizona.

The Nile would probably dry up before it flowed its long course were it not fed from the humid lake region of Africa. So would the Colorado perhaps during part of the year were it not fed by the snows and rains from the high and humid mountains, because it flows through a Sahara-like region in its lower course. As the rainfall around Yuma is but from two to fifteen inches per year and it has the reputation of being one of the hottest places in the country, the highest official temperature being 118 degrees in the shade, it can be readily understood that irrigation is absolutely necessary if any crops at all are to be raised.

The Gulf of California originally extended 150 miles farther northwest than it does to-day; it extended as far as Indio.

The Colorado is a muddy river and brought down thousands of tons of sediment, the wear and tear of the western part of the continent, produced by erosion. As it poured its waters into the Gulf the velocity was checked and the sediment deposited produced a delta. Even at the present day it is calculated by the Reclamation engineers that the Colorado River in twenty-four hours during a high flood carries past the dam site 1,500,000 tons of silt. In past times this delta traveled southwest across the Gulf and finally isolated the northern portion of the Gulf entirely.

In a region whose torrid heat is almost tropical and where evaporation is exceedingly rapid, an average of at least eight feet per year, this isolated inland sea gradually evaporated and left a large depressed area, most of which is below sea level. The old beach line is plainly visible in the north and is on a level with the Pacific. This area north of the Mexican boundary line is now known as the Imperial Valley. The deepest part of this valley contains the so-called Salton Sink, now called the Salton Sea, and is over 300 feet below sea level. From time to time the Colorado overflowed its banks and de-



Reversed abbatis and screen dike for the protection of the Yuma Valley dike, five miles west of Yuma, Arizona

posited silt rich in plant food over the floor of the valley, so that much of the Imperial Valley contains fertile soil. There were two parallel dry river courses or arrovos which extended from the Colorado River northwest and emptied into Salton Sea. As a rule the high water in the Colorado only overflowed enough to fill these rivers for a short distance from their sources, and it was a rare occasion for the Colorado to overflow sufficiently for its waters to reach the Salton Sea. In 1891 these rivers were not only filled but overflowed their banks and the surrounding country and in some places even united, as they were

but a few miles apart. The Salton Sea rapidly increased in volume.

The report of the Mexican Boundary Commission states "that the channels of these streams are fringed with a thick growth of mesquite while the limits of overflow are plainly marked by a most luxuriant growth of an amaranthus (called quelite by the Mexicans), a plant much esteemed as food for cattle. The growth of quelite, mesquite and grass following the overflow of 1891 furnished a fine pasturage for several thousand head of cattle, brought here from the overstocked ranges of Arizona and California."

This Imperial Valley was practically uninhabited then, but when the settlers saw the abundant forage crop produced by the overflow of the river they reasoned that by diverting the Colorado into canals and irrigating ditches the desert would bloom like a rose. Finally in this desert valley 100,000 acres were irrigated, new towns started connected by branch lines to the Southern Pacific Railroad system. The people poured into this fertile valley almost like the exodus from the settlements into a new mining camp when a rich find is made, until nearly 10,000 people were living below sea level in a valley which was once a trackless desert waste, made fertile by irrigation. One of the canals that the settlers built tapped the Colorado just a short distance below the Mexican boundary line. Of course it was down grade from there to the Imperial Valley. They simply ran the canal into one of the dry streams or arroyos and gave it the name Alamo River. There were no headgates to regulate the flow, so that during a time of flood when the Colorado was unusually high the greater volume of water left its usual river channel and poured its waters into the canal and finally reached the Salton Sea through one of the river courses formerly called Alamo River. This sea is now an immense inland body of water increasing in size. The New River channel also filled and finally these two streams united forming a stream several miles wide flowing into the Salton Sea. The Southern Pacific Railroad tracks have been submerged. At Salton one of the most remarkable and valuable deposits of salt in the United States was ruined by the rising waters. There was a field of salt of 1000 acres where the crust formed from six to sixteen inches thick looking like a great deposit of

snow. It was of unusual purity (95%) and was simply plowed and raked into rows. The salt would soon form again after it was raked from the marsh. The waters of Salton Sea continued rising until the salt fields were submerged. The Southern Pacific tracks were moved twice and finally the telegraph poles were covered. The curious sight of fields of waving sage brush and other desert plants along a shore line of white caps is seen.

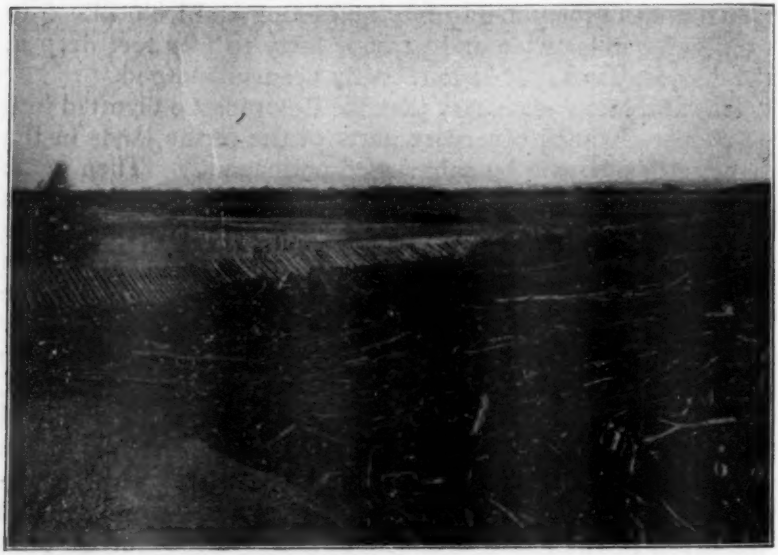
The Colorado is still pouring its water into the Salton Sea which is daily rising. The dimensions of this sea at the time of writing (September, 1906,) I am not certain of, but estimate that it is from forty-five to fifty miles long and from fifteen to twenty-five miles wide and perhaps forty to fifty feet deep in the deepest parts that have recently been submerged.

It is absolutely necessary that the Colorado be diverted into its proper channel, otherwise parts of the fertile lands in the Imperial Valley will be submerged permanently. Then again it is not fair to our sister Republic, Mexico, because thousands of fertile acres on the other side of the boundary line will be rendered worthless without irrigation. A dispatch from San Francisco dated August 24th states that the Salton Sea in the Colorado Desert is now rising less than an inch a day and they expect in a few weeks to begin work on a plan by which the Colorado River will be restored to its original channel. This, it is stated, will probably cost the Southern Pacific Railroad $700,000. Heavy embankments are to be built where the river is overflowing into old channels. This will be a tremendous undertaking and an engineering feat of rare skill, as the break in the banks of the Colorado is three-fourths of a mile long. The water of the Salton Sea will soon evaporate when the overflow is stopped.

This description of the Salton Sea and the overflow of the Colorado River are features that could not be omitted from an article on irrigation near Yuma.

The irrigation dam which the Government engineers are building is located twelve miles above Yuma at Laguna. It will not rest on rock because borings did not reach bed rock, which is buried under many feet of silt. The dam, which stretches across the river channel from bank to bank, will have a length of 4780 feet, its height will be but nineteen feet, but

its width up and down stream will be 267 feet. Its contents will be 356,000 cubic yards, the weight about 600,000 tons and the cost about $1,000,000. It will hold back the waters of the Colorado, forming an artificial lake about ten miles long. The dam is of the East India weir design and has been tried at many places in Egypt and India. On the Nile River to-day they are in successful operation and the conditions there are similar to Yuma. The solid masonry rests on sand and silt. For these later facts about the dimensions and construction of the dam, disposition of silt and other details, I am indebted



Reversed abbatis constructed for protection of Yuma Valley dike, about five miles west of Yuma, Arizona, showing accumulation of driftwood during one flood. Yuma project, March 31, 1906

to the Reclamation Service and to excellent articles by J. B. Lippincott, Supervising Engineer, (Annual Report Smithsonian Institute, 1904,) and C. J. Blanchard, Statistician of U. S. Reclamation Service, (National Geographic Magazine, February, 1906.)

The engineers explored with the diamond core drills all the sites between Yuma and Picacho for bed rock before the Laguna site was selected. They considered a high dam and a

high line canal out of the question. Mr. Lippincott describes the weir dam as follows:

"This type of weir consists of loose rock structure with a paving of stone two feet in thickness on the down stream slope, the structure being tied together with three parallel walls of concrete run longitudinally between the granite abutments on the two sides of the river, and the entire structure being further made secure by an apron of loose rock pitching ten feet in thickness and fifty feet in width at the lower toe of the dam below the sloping pavement. The height of this weir is to be ten feet above low water and the slope of the down stream side is twelve feet horizontal to one foot vertical, with the fifty foot apron below. The design calls for the upper core wall of concrete to rest upon a row of sheet piling driven into the bed of the river. The handling of the silt he states is one of the most difficult features of this undertaking. It is known that its amount is very large.

"The river is on a grade of approximately one foot to the mile above the Laguna weir site, so that this weir, ten feet high, will make a settling basin of relatively quiet water, approximately ten miles in length above it. At each end of the weir and constructed in solid granite rock will be a sluiceway 400 feet wide on the Arizona side and forty feet wide on the California side, with provision for its enlargement to 200 feet when desired, and excavated to the depth of two feet below low water in the river. These sluiceways will be closed by large gates operated mechanically. The diversion canals will take their water above these gates from the sides of the sluiceways. The area of these sluiceways being so great, the water movement toward the canal will be slow, and most of the sediment will be deposited before reaching the canal intake. When this has accumulated to a considerable extent, the sluice gates will be opened, and it is estimated the flow will be approximately 20,000 cubic feet per second. This great volume of water passing through the sluiceways when the gates are opened will carry out with it the sediment deposited above the intake of the canal. The ordinary low stage flow of the Colorado River is from 3000 to 4000 cubic feet per second; so that the capacity of these sluiceways will be about five times the low

water flow of the river. These figures are given for the purposes of comparison only.

"As the result of a number of experiments it has been found that the principal quantity of silt is carried along near the bottom of the river and that the surface water is relatively free from sediment. It is planned therefore to take the water into the canals by a skimming process over a long row of gates, so that the entire capacity of the canal can be furnished by drawing but one foot in depth of water from the surface of the river. Every portion of this weir and headworks as designed would be of rock concrete or steel with the exception of the sheet pilings, which will be driven entirely below water level and so will not decay. The capacity of these canals at their intake will be 1600 cubic feet per second on the Arizona side and 200 cubic feet per second on the California side. The amount of silt that would be daily delivered into the Arizona canal if diversion were made directly from the stream would approximate 17,000 cubic yards of wet mud by volume. It is not believed to be possible for a canal to continuously operate successfully for the irrigation of lands along the valley of the Colorado River unless some very substantial arrangements are made at the headworks for the handling of silt, and this is believed to be a justification for the expenditure proposed for these headworks; also the water must be held to a fixed level at the canal heading for all stages of the river. This structure will cost approximately $1,000,000. It is not considered possible to remove all of the silt from the water, but the canals have been designed so that the velocities will be sufficient to convey through to the fields the light material entering the canals from the intake.

"One of the most difficult problems in connection with this project is the crossing of the Gila River. It has been considered necessary to make this perfectly safe and for this purpose a structure has been designed that will cross beneath the bed of the river, the top to be several feet below the lowest point of the stream bed. This structure will be of steel and concrete some 3000 feet in length. It will be an inverted syphon consisting of four concrete pipes ten feet in diameter reinforced with steel rods. Because of the annual rise of the Colorado River, a large portion of the lands along this stream are sub-

ject to annual overflow, which practically prevents residence thereon, as well as the farming of them without protective works. The levee therefore is considered an essential feature of the enterprise. The shape of the levee adopted is one that has been developed by years of experience along the Mississippi River. It will have a slope of three feet horizontal to one foot vertical on the water side, and two and one-half feet horizontal to one foot vertical on the land side. It will be eight feet wide on top, and be built five feet above the highest water marks of the year 1903. These levees will be 4000 feet apart (one on each side) along the Colorado River and 3200 feet apart along the Gila River. Because these lands are so flat and the level of the water in the ground so near the surface, it is considered necessary for their permanent safe irrigation to supply a drainage system. A main drainage canal has been designed to run through the central portion of the areas to be irrigated and when possible the natural drainage lines of the country will be utilized, deepening them with a steam dredger to such depth that they will carry off the water returning from irrigation or seepage through the levees during the high water stage of the river. When lands in any district tend to become alkaline they may be connected by means of local drainage canals, with this main drain, and in this manner they could be kept free from alkali by holding down the level of the ground water. During the greater portion of the year when the river is low, this drainage water would be discharged into the stream, but when the river is in flood its elevation will be such as to prevent a discharge into it from the drains. A pumping plant has therefore been designed to lift the drainage waters over the levees during the flood period of the river to prevent the lands becoming water logged.

"The Secretary of the Interior has set aside $3,000,000 of the Reclamation Fund for the construction of this project, contingent upon the action of the landowners of this valley and their entering into contracts with the Department in accordance with the provision of the Reclamation Act, passed June 17th, 1902. On March 15th, 1905, bids for the construction of the dam were opened and responsible bidders offered to build this structure for the amount estimated upon by the engineers."

Too much praise cannot be awarded Mr. F. H. Newell, Chief of the Reclamation Service, and the very able body of engineers under the employ of the Government. One has only to study the water supply and irrigation papers and the annual reports of the U. S. Geological Survey that treat of hydrography to learn of the thousands of painstaking observations that were made before the irrigation projects were planned.

The projects require engineering skill of the highest order. The Roosevelt dam in the Salt River Cañon, Arizona, will be solid masonry 285 feet high, and will join the cañon walls several hundred feet apart and form a lake twenty-five miles long and 200 feet deep. The United States will soon take the lead as the foremost country where irrigation is practiced on a grand scale.

EFFECT OF DURATION OF STRESS ON STRENGTH AND STIFFNESS OF WOOD.

It has been established that a wooden beam which for a short period will sustain safely a certain load, may break eventually if the load remains. For instance, wooden beams have been known to break after fifteen months under a constant load of but 60 per cent of that required to break them in an ordinary short test. There is but little definite and systematic knowledge of the influence of the time element on the behavior of wood under stress.

This relation of the duration of stress to the strength and stiffness of wood is now being studied by the Forest Service at its timber-testing stations at Yale and Purdue Universities. The investigation should determine: the effect of a constant load on strength; the effect of impact load or sudden shock; the effect of different speeds of the testing machine used in the ordinary tests of timber under gradually increasing load; and the effect of long-continued vibration.

To determine the effect of constant load on the strength of wood a special apparatus has been devised by which tests on a series of five beams may be carried on simultaneously. These beams are two and three inches in section and thirty-six inches in length, each under a different load. Their deflections and breaking points are automatically recorded upon a drum which requires thirty days for one rotation. The results of these tests extending over long periods of time may be compared with those on ordinary testing machines, and in this way safe constants, or "dead" loads, for certain timbers may be determined as to breaking strength or limited deflections.

The experiments of the Forest Service show that the effects of impact

and gradually applied loads are different, provided that the stress applied by either method is within the elastic limit of the piece under test. For example, a stick will be bent twice as far without showing loss of elasticity under impact, or when the load is applied by a blow, as it will under the gradually increasing pressure ordinarily used in testing. These experiments are being extended to determine the general relations between strength under impact and gradual loads.

Bending and compression tests to determine the effect of the speed of application of load on the strength and stiffness of wood have already been made at the Yale laboratory. The bending tests were made at speeds of deflection varying from 2.3 inches per minute to 0.0045, and required from twenty seconds to six hours for each test. The woods used were longleaf pine, red spruce, and chestnut, both soaked and kiln-dried. From the results are obtained comparable records for difference in speeds in application of load. A multiplication of the results of any test at any speed by the proper reduction factor, derived from these experiments, will give equivalent values at standard speed. The tests also show concretely the variation of strength due to variations of speed liable to occur during the test itself. The results plotted on cross-section paper give a remarkably even curve as an expression of the relation of strength to speed of application of load, and show much greater strength at the higher speeds. A numerical expression of the law, averaging all species, both wet and kiln-dry, gives the following table, which shows the increase in strength with the increase of speed of tes :

Minutes to move crosshead one inch.	Ratio of ultimate strength	
	Compression.	Bending.
900	100	100
350	100.8	100.9
150	102.3	107.3
40	106.9	110.1
5	113.8	118.7

The first column, which gives the number of minutes required to move the crosshead of the testing machine over the space one inch, is the reciprocal of speed. The second and third columns give the effect of this increase of speed upon compression and bending, respectively, and show that strength increases with speed. The strength at the lowest speed is arbitrarily fixed at 100 as a convenient basis for comparison. The ordinary bending-test speed for small specimens is one-tenth inch per minute, or,, reciprocally, 10 minutes are required to move the crosshead one inch.

It is common belief among polemen that the continual vibration, to which telephone poles are subjected, take the life out of the wood and render it brash and weak. Nothing is definitely known as to the truth or falsity of this idea. Tests will be undertaken to determine the effect of constant vibration of the strength of wood. [Trade Bulletin No. 10, Forest Service, U. S. Dept. of Agriculture.]

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